NATURE

No. 4114 SATURDAY, SEPTEMBER 4, 1948 Vol. 162

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Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

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SECOND THOUGHTS ON UNIVERSITY EXPANSION

THE almost simultaneous publication of the Nuffield College Statement "The Problem Facing British Universities" and the symposium on "Entry and Careers" in *The Universities Quarterly* for August provides valuable material for further discussion on the expansion of the universities. The former Statement brings together much useful statistical information as well as collecting in its chapters on the demand for university graduates estimates of intake to the professions which are not otherwise conveniently accessible. Moreover, in the further chapter on the flow from the schools the Statement does something to meet a point made by Dr. Eric James, high master of the Manchester Grammar School, at the British Association conference on "The Place of Universities in the Community" last year, as well as to supply a factual background to Dr. J. F. Mountford and Mr. James Hemming's contribution to the symposium. Indeed, the Statement contains so much factual information that it is not easy to see the wood for the trees, and the conclusions seem to indicate that the members of the Nuffield Committee have not been entirely sure of themselves for that reason.

The Statement sets out in the first place to survey the chief demands made on universities, and after reviewing those made by the organised professions and other regular occupations which rely for recruitment on university graduates, including the demand for admission from overseas students, which is expected to be strong for some time, it considers the extra-mural work of the universities and the position of the higher technical and other specialized institutions. While the Statement does not commit itself to any quantitative estimate of the extent of university expansion, the Committee regards a permanent expansion as probable and appears to be satisfied that there is little risk of the large number of graduates failing to find employment. On the other hand, it formed the opinion that in the aggregate present demands are probably exaggerated, and that if the demands are pressed separately and dealt with piecemeal without consideration of their interrelation and aggregate effect, there may be real danger that legitimate but sectional needs will be met to the neglect of other needs of greater importance to the maintenance and development of the universities.

The Statement is thus first and foremost a challenge to fresh thought about the purpose and functions of a university, and as a result of that thinking to determine principles by which sound decisions can be made in balancing new claims against existing duties or one new claim against another. The Nuffield Committee does not, it is true, go very far in its analysis. It insists that in the first place there must always be an element of general education or culture in the teaching a university gives, and that, in the second place, this teaching must be given by scholars and men of science who are themselves working at the frontiers of knowledge. A university must maintain a reasonable range of studies, and not allow its desire to meet any one claim to turn it into

a specialized institution restricted to serving the needs of a single profession or field of research, nor must any aggregate demands for teaching be allowed to deflect its staff from pursuing their own studies and research. The Committee observes here that it is at least a possibility that in the endeavour to give everyone whatever he wants, the universities may end by giving nobody what he requires.

The two chief suggestions made in the Statement to relieve the universities in meeting the immediate and short-term problems of expansion will be discussed in due course. The Committee recognizes that there is no satisfactory solution to the problem of meeting under present conditions the sudden expansion in the demands made on the universities. Its suggestion as to the extension of the extra-mural work of the universities has a bearing, however, on the long-term problem of expansion with which the universities are simultaneously faced.

The Statement suggests that universities which are adequately staffed might extend the opportunities which they offer to part-time students already qualified by previous education by allowing such students who are prevented from full-time residence to spread their study over a longer period than the usual full-time period, and by the provision of short special courses of the refresher type for those who can only come for a short period. The emphasis thus placed on the extra-mural and regional responsibilities of the universities is welcome: no short-term policy even which severely restricted the discharge of such responsibilities could wisely be accepted. Nevertheless, the Statement does not make it clear how the continuance or extension of such functions will contribute to ease either the short-term or long-term expansion. Like the question of size, on which also the Statement briefly comments, these functions appear to be mentioned chiefly as essentials to be kept in mind in deciding the exact purpose and functions of the universities.

Where the Statement is most disappointing is not so much in not indicating the Committee's own conception of a university and the precise purposes and functions it should serve, as in the absence of any constructive suggestion as to how we are to formulate such a conception or definition or to deal with those questions of geographical distribution of universities and the distribution of university resources among different projects where some co-ordination and concerted effort are essential. It rejects the proposal for a royal commission on universities as imposing a further burden on university administrators and teachers who are already overtaxed, without offering much hope of any kind of an early solution of problems. But to the crucial question whether the universities and the present University Grants Committee are competent to effect such a survey of needs and reforms or whether an external agency is required it gives no answer; but merely states the arguments for the alternative courses.

These arguments are admirably put, but what is required at the moment is decision. The Nuffield College Statement makes curious reading on this point, with Lord Lindsay as one of the signatories. Lord Lindsay's plea in the House of Lords debate on the universities in May of last year for a comprehensive review of the situation as a whole by some body other than the University Grants Committee is perhaps the most convincing argument yet advanced, not for the departmental committee which he suggested, but for the comprehensive and comparative survey which a Royal Commission alone could be expected to make.

However right it may be to hesitate to designate men and women for such a task when our ablest administrators are already often seriously overworked, that exigency is no more valid a reason for not examining the whole problem at the highest level than it is for not carrying out that survey of the machinery of government at the Cabinet and ministerial level for which the Select Committee on Estimates called in a recent report. Failure to conduct either survey may, and almost certainly will, involve waste of man-power at all levels immensely out of proportion to that involved in conducting the survey. So far as the universities are concerned, the brake on expansion imposed by the building situation may well afford the necessary breathing space for such a survey if a prompt decision is made as to the instrument to be used to conduct the survey. Nor need, it might be added, a royal commission, as opposed to the University Grants Committee, or some sub-committee of that body, employ the time of more than a very few of those actively engaged in university administration or teaching. Not only is there a sufficient reservoir of able minds with some experience and understanding of university problems, but much of the information is already being accumulated by various independent means or bodies; these activities and results require bringing together in a composite picture upon which judgment and decision can be based.

Except in respect of science students, where the analysis of available figures is somewhat limited, the Nuffield College Statement provides a fairly detailed comparison of the expansion of the different universities and university colleges in 1945–47 as compared with the situation before the War. The most interesting feature of the symposium in *The Universities Quarterly* already noted is the reference to a number of inquiries already conducted by the Technical Personnel Committee set up by the Ministry of Labour and National Service under the chairmanship of Lord Hankey, some of which do not appear to have been published. The quotations from these reports are complementary to the information in the Nuffield Statement and help to fill in some of the gaps that exist in our knowledge of the present situation and the probable demand for particular classes of graduates.

It is well known that while in the autumn of 1947 the number of students in British universities had risen from the pre-war 50,000 to roughly 77,000, the number of science students had practically doubled and stood at 14,500. As regards arts students, if the student population remains at about 80,000, there are expected to be about 12,000 graduates in each

year from 1951 as against 7,000 before the War. In spite, however, of this increase in the number of science students, no substantial increase in the output of graduates available for employment outside the universities is expected before 1950. Thereafter there should be a rapid increase to about 5,000 each year or double the pre-war output. The first substantial increase in graduates in technology will likewise not be effective industrially until 1950, owing to the demands of military service, but by 1951 the output should be 3,400 each year as compared with 1,500 pre-war.

These are figures of which not only the universities but Government Departments as well as the universities should take careful note, and they should certainly guide the Advisory Council on Scientific Policy in considering the distribution or re-distribution of scientific man-power. Moreover, when the development plans of both large and small firms are already impeded by their inability to secure the recruits they require for research and production, with all that involves for industrial recovery and export, the situation disclosed by Mr. L. E. Ball in regard to particular categories is disturbing.

Mr. Ball, the secretary of the University of London Appointments Board, states in this article that there are at present sufficient chemical appointments vacant to absorb all new graduates in chemistry up to 1949 and that demand appears to be increasing steadily. Again, the Technical Personnel Committee, according to Mr. Ball, estimates the demand for chemical engineers for the next five years to be 240 a year as compared with a present annual output of less than 100. The reduction in new construction has, however, reduced the demand for engineers, and in engineering generally it seems that supply is in excess of demand.

This report from the Technical Personnel Committee would seem to be one of three reports which, according to Mr. Ball, have already been issued. One relating to mycologists and microbiologists, stated to have been issued in July 1947, indicated that the present output of microbiologists and mycologists is adequate and that a large expansion is not justified. A similar statement has been made of architects, and generally such inquiries as have been made by the Ministry of Labour and bodies like Political and Economic Planning indicate that most of the professional organisations do not expect any large increase in numbers once their war-time gap has been filled. Mr. Ball, however, expresses the hope that other reports dealing with chemists, biologists and physicists will come from the Technical Personnel Committee without delay, and the figures for physics honours students quoted by Sir Lawrence Bragg were presumably collected for this Committee.

Sir Lawrence Bragg points out that the honours physics schools of our universities are now producing about 600 graduates annually in place of a little more than 200 before the War, and returns from the universities indicate that this number is likely to be maintained for the next few years. Of these graduates in 1947 some 31 per cent entered careers in university or government research as against 29 per cent in pre-war years, 19 per cent entered industry in place of 30 per cent, and only 12 per cent took up a school teaching career as against 29 per cent before the War.

These figures are no less disturbing than those for chemistry graduates, and although the symposium in *The Universities Review* does not give any clear idea of the magnitude of the university expansion at which we should aim, it reinforces the argument for a comprehensive review of the whole situation and points also to the importance of associating industry with this review. Even from a short-term point of view the distribution of scientific man-power needs to be watched closely or there may be as serious repercussions on the flow of students to the universities for science courses as through the inability of industry to recruit the scientific workers it needs now so imperatively for research and production. Moreover, it seems clear also that only with the help of industry can serious unemployment among those who have graduated in arts be avoided during the next four years. Only in industry can openings be found for a considerable surplus over those who can find places in teaching and the professions, and there is real call for business men and industrialists to re-examine their recruiting policy and reconsider their needs for competent managers at the lower salary levels as well as at the directorate levels

At the entry side, both Sir Lawrence Bragg and Mr. J. Hemming direct attention to the question of quality. There seems to be little doubt that Great Britain's reserves of innate intelligence are sufficient to provide annually another 50,000 students of as high mental ability as those attending before the War. There is some doubt as to whether all those students would be forthcoming with the other specific aptitudes, including cultural standards, to make the most of a university life. Mr. Hemming is hopeful but Sir Lawrence is dubious. He has formed the impression that while we have not been missing many first-rate people, we are admitting to honours courses too many who would have profited more by training in much less ambitious courses.

The question of selection of students will be brought to the fore when the Working Party in State Scholarships and Major Awards reports to the Minister of Education shortly. The question of the cost of university education on which Mr. P. F. Vowles just touches in the concluding article in this symposium is bound to become increasingly prominent in discussions on university expansion. However fully we may subscribe to the belief that university education is an investment, it must be recognized that both the universities and the State have a duty to see that the considerable sums involved are wisely spent. It has been estimated that it costs £3,000 to provide a student at Cambridge with a three-year course. Even if his parents are prepared to pay £300 towards it, £2,700 has still to be found from public or university funds. Expenditure at the provincial universities is much less, but neither there nor at Cambridge can the nation as a whole afford to spend such sums on individuals who possess neither the brains nor the personality to profit from them.

Neither the Nuffield College Statement nor the symposium in *The Universities Review* does much more than indicate the range of problems to be solved and the imperative need for dealing with them as a whole and not piecemeal. Both challenge creative thinking about the purposes and functions of a university. Both indicate the urgent need for decision as to the body to whom that overall review is to be entrusted and for swift action as soon as the facts can be fully assembled and considered judgment made. It seems equally clear that if the nation's reserves of intelligence are to be trained and distributed to the best advantage, in that review must be joined the best minds that not only the universities but also industry and the nation as a whole can supply.

EVOLUTION IN MANKIND

A New Theory of Human Evolution

By Sir Arthur Keith. Pp. x + 451. (London: Watts and Co., Ltd., 1948.) 21*s.* net.

THIS book is the fruit of a long life of scientific work and meditation by a distinguished thinker with strong intuitions, trying to look towards a synthesis as yet seen 'through a glass darkly', and trying to make that vision clearer without limiting possibilities of its future adjustment. There is no attempt to force the facts to fit preconceived dogma, no riding of a pet theory to exhaustion.

The basic idea is derived mainly from Darwin, Romanes and Gulick. It is that isolated small, inbred groups are likely to diverge. This view is strengthened by the work of the geneticists, who show that in such a group dominant genes are likely to spread generally among the members, especially if they carry some character of value in the environment concerned. Defective genes may bring rapid extermination, especially if emphasized by close inbreeding.

Keith emphasizes the smallness of the hunter-collector groups in several environments; and he might have made more of the probability that in that stage of social-economic development, Britain is not likely to have had more than a few hundred people in scattered small groups. He directs attention very justifiably to the territorial bases of the little early group which he, in common with all other scientific observers, regards as a basal feature of our heritage from prehuman ancestors. Society is not primarily a human construction, and whatever we may say about social elaborations, they are, as it were, shoots on a prehuman trunk. The territorial basis may be a hunting-range, including perhaps a water supply and so on; the group will typically resent intrusions of strangers and will combine to defend the territory. Here we have Spencer's code of amity within the group and code of hostility outside it, both features of the ethical make-up of mankind, the disharmony between which is our permanent problem. But Keith is concerned with the fact that the code of hostility promotes inbreeding and differentiation, in language and custom as well as in physique; and, at an early stage, the more diversity the less interbreeding. Differences of language and custom are thus factors of isolation which he thinks may be more powerful than mountain or desert belts.

The small group has tended to remain poor, and larger associations of groups have come into existence, with decreasing uniformity in physique, but sometimes enforced uniformity in language and custom. Inbreeding, dangerous as well as sometimes useful, is less and becomes less still when one group conquers another, and the conquerors, mainly young men, take to themselves the girls of the conquered people. The larger and more complex group has more to defend, and around this gathers the emotion of patriotism; this in turn promotes breeding within the group, so the self-conscious, patriotic group may differentiate itself, even physically, from others in the course of time. A tribesman, says Keith, is apt to transfer his own emotions and impulses to his tribe or group, and we know the power of that group impulse, especially in connexion with the code of hostility. Russel Wallace was the first to emphasize group-solidarity and the accompanying selection between groups as a factor of evolutionary differentiation.

Keith emphasizes fœtalization as a factor of evolutionary differentiation. The forehead and many other features in women are usually nearer the fœtal stage than those of men. Mongol features, so called, including a low and retracted nasal bridge, an epicanthic fold over the upper eyelid and protuberant eyeballs, are fœtal and transitory in a proportion of Europeans, but durable in parts of Eastern Asia and among the majority of Hottentots. These resemblances are not necessarily indications of close genetic relationship.

It has seemed best to try here to give a fairly general picture of Keith's views. The book reviews many stages of human social, as well as physical, differentiation and gives the author's considered opinions. He adheres, for example, to the view that the Piltdown skull and jaw belonged to one and the same individual, arguing against the opinion that they are of different species but not mentioning the bare possibility that the skull might be that of a female and the jaw that of a male.

Keith's idea of inbreeding groups as in process of differentiation leads him to think of them as possibly races in the making; but most groups of the present time are heterogeneous and likely to remain so, and it might be better to use some term other than that of race in this connexion.

The book is one for careful meditation, and is an interesting monument of a respected and beloved personality.

H. J. FLEURE

TOWARDS A MATHEMATICAL SOCIOLOGY

Mathematical Theory of Human Relations

An Approach to a Mathematical Biology of Social Phenomena. By N. Rashevsky. (Mathematical Biophysics Monograph Series, No. 2.) Pp. xiv + 202. (Bloomington, Indiana: Principia Press, 1947.) 4 dollars.

IT is only in quite recent times that mathematical methods have been applied in the social sciences or, indeed, in those fields, such as psychology, where the natural and the social sciences overlap. The use of mathematical-statistical methods in the handling of data, as in biometrics or econometrics, has developed rapidly in recent years. The employment of mathematics as a tool of analysis in the development of theory has been neither as general nor as successful. Mathematical economics, like mathematical biology,

is taking its place in the general body of theory, and the time is ripe for extensions into other social sciences. What the author of this book attempts is a sketch of the possibilities of a mathematical sociology. He is where the mathematical economist or biologist was some decades ago, experimenting with alternative formulations and various types of simplification. He has a wider and more difficult field than the economist or biologist but; since his science overlaps with theirs, he can draw upon their experience.

I can give no more than a brief indication of the scope of the author's essay. He attempts a theory of the way in which classes or groups are formed, of their size and number. He considers the interaction of one group with another within the social structure and, in particular, the various kinds of conflict from economic exploitation to war. He develops the characteristics of individualistic as against collectivistic societies. He has a good deal to say on the dynamics of the growth and decay of groups; for example, the controlling power of a group, derived by inheritance from past generations, may become unstable. He finds that a rather general formulation involves complicated integral equations; but, by simplification of his models, he is able to proceed with differential equations and with ordinary problems of maximum and minimum.

The author would, I think, agree with me in stressing two aspects of his work. One is that he is experimenting with various mathematical formulations, most of which may not lead to anything fruitful. Even so, the work is not wasted. It is always useful to translate into mathematical terminology the different theoretical situations studied; in this case the growth and interactions of groups in the social structure. This serves, at least, to clarify the nature of the assumptions on which the theory rests and to distinguish sharply between the various possibilities.

The second aspect is that, eventually, any mathematical theory must be developed to the point where it can be put to the test with actual data and lead to prediction. The author's theoretical constructions are, he admits, crude and oversimplified descriptions of a modern society. But, if only for illustrative purposes, he ventures to introduce actual data from time to time to match against his theoretical results.

Against these merits must be set certain weaknesses, many perhaps inevitable in a pioneering study. I think the author has been ill-advised to publish his work in book form so early in its development. With more time, he might have shown greater discrimination in his selection of formulations for development; he might have cut out some weaker threads and tied up some of the stronger but loose ones. He is at his weakest where he analyses the economic aspects of social groupings. He admits that much of what he does must appear crude to an economist, but feels that his simple approach is necessary to "bring out the social aspect of the interrelation of economic classes" (p. 40). Perhaps so, but I feel that he can only say this after a close examination of the work of mathematical economists. His references make it clear that he has not read widely in this field. He is much influenced by two or three writers, particularly G. C. Evans (referred to throughout as G. E. Evans), whose work dates back to the 1920's and early 1930's. He displays no knowledge of later work, particularly in economic dynamics, which would be of more help to him. He would find, for example, that mathematical economists first followed physicists in using differential equations but afterwards turned to difference equations as more appropriate to their subject, and (incidentally) discovered them to be just as easy to handle. His assertion that "no successful application of mathematics to social phenomena has been made" (p. iv) is not true of at least one branch of the social sciences.

R. G. D. ALLEN

THE UNIFORM CALCULUS

A Text-Book of Mathematical Analysis

The Uniform Calculus and its Applications. By R. L. Goodstein. Pp. xii + 476. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 30s. net.

THE problem of presenting the infinitesimal calculus to schoolboys and university students who seek to acquire a knowledge of it for applications in other fields is notoriously difficult. Methods based upon geometrical intuition lack rigour and to the thinking student produce an impression of mystery. Methods based on a rigorous theory of real numbers are suited only to the student who is to become a mathematical specialist.

Dr. Goodstein proposes to avoid the difficulty by a simplification of the calculus itself, by restricting his treatment to functions which possess uniform differentiability. The foundation-stone is the notion of a convergent sequence of terminating decimals, which is then extended to convergent sequences the terms of which are endless decimals. The notation $0(r)$ is used to signify any number which is zero to r places of decimals, that is to say, a number the positive value of which is less than $1/10^r$. A function $f(x)$ is said to be uniformly differentiable in the interval (a,b) if we can find functions $f'(x)$ and $n(r)$ such that

$$\frac{f(X) - f(x)}{X - x} = f'(x) + 0(r)$$

for any numbers X, x in (a,b) which satisfy $X - x = 0(n(r))$.

The (uniform) derivative $f'(x)$ thus defined exists for all the usual elementary functions which the student is likely to encounter, in particular for the circular and exponential functions.

It is then proved that a uniform derivative is a continuous function, and that a function uniformly differentiable in (a,b) is continuous in (a,b).

On this basis, and with suitable definitions of integrals, the uniform calculus is built up in such a manner that the ideas can be appreciated by a student who has only a modest knowledge of arithmetic and algebra.

The first eleven chapters contain all the calculus that is needed for the ordinary and advanced papers of the higher school certificate examinations. The whole book covers the calculus syllabus for the general honours degree of London and provincial universities and the London special degree.

The demonstrations are lucid and often original, and the student should profit by the examples of technique so well illustrated in every chapter. The standard functions e^x, $\sin x$, $\cos x$ are defined by their expansions in power series and are introduced in a natural and satisfying manner.

The author has purposely given no diagrams in order to prevent the possibility that geometrical intuition may disturb algebraic reasoning. One might, however, expect a certain amount of sales resistance from a certificate student to the statement that the area bounded by a simple closed curve is

$$\left| \tfrac{1}{2} \int_{t_0}^{t_1} (xy' - x'y)dt \right|,$$

with the added note that a rigorous proof belongs to the theory of double integrals and is postponed to Chapter 17.

The book is certainly a contribution of outstanding merit to the very few serious efforts which have been made to present limiting processes to the student at a level which he can readily understand, and which at the same time will leave him nothing to unlearn at a more advanced stage. The book contains more than four hundred worked examples.

L. M. Milne-Thomson

SCIENCE IN RELATION TO HISTORY

Science and its Background

By Lieut.-Colonel H. D. Anthony. Pp. ix + 304. (London: Macmillan and Co., Ltd., 1948.) 10s. 6d. net.

THERE are many ways in which authors have dealt with the history of science. This important subject can appear as a plain chronology of scientific development without any account of its relations to contemporary thought, it can take the form of a series of 'great lives' given with anecdotal treatment, or it may trace the parallel evolution of philosophic thought at each stage. The work here reviewed is eclectic in its methods: it envisages the story of science through history, and, moreover, a history which takes account, as all histories should, of human development and the evolution of social institutions. The author, a former grammar school headmaster, is the chief inspector of education in the British Army, and if the contents of the book are an indication of what is done in adult education in the Services and elsewhere it is a happy sign of the times. In its three hundred pages the book deals with many subjects. The author has succeeded in being succinct without being superficial by a careful selection of the most important topics for his purpose.

The form of the book is original in its layout and in the grouping of the material. The great movements in the advance of scientific knowledge are considered under the following headings: the beginnings of science in the "Rivers Period", the Mediterranean Period (Classical and Medieval), the Atlantic Period (Renaissance to Modern), the World Period (International Conflict and World Co-operation).

The main need in the teaching of science at present is not an improvement in practical techniques, nor of further specialist subdivisions of the science subjects. The dichotomy between what so often passes in school and university for science and culture is a matter which exercises the minds of many mid-twentieth century thinkers. There is an urgent need for seeking a new synthesis, and as a guide the book here reviewed would make a good introduction. The author is always fair, and evinces no emotional, political or religious biases which make a mockery of the scientific spirit and mar so many works on the relations of science with other forms of human activity.

The book should be read by every sixth-form pupil, whether of arts or science. For the lay-reader requiring a short, readable and accurate account of the growth of science in its human context, it is difficult to see how it could be improved.

The production of the book in general and its pictures and time-charts in particular reach a high standard.

W. L. Sumner

INSECTICIDES AND FUNGICIDES

A Catalogue of Insecticides and Fungicides

Vol. 1: Chemical Insecticides. Compiled by Prof. Donald E. H. Frear. (Annales Cryptogamici et Phytopathologici, Vol. 7.) Pp. xii + 204. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1947.) 6.50 dollars.

THERE is a large and expanding literature concerned with the control of insect pests by the use of chemicals, derived either from plants or synthesized in the laboratory. The number of compounds tested for this purpose is already very great, and the relevant information is scattered through many original papers. Many workers in this field undoubtedly have references to much of it filed away, but it is only the relatively widely used compounds that are essentially borne in mind when particular problems arise. Not only so, but in all branches of human knowledge the recording and indexing of information demands great expertness if it is to be readily available. Prof. D. E. H. Frear has obviously applied considerable expertness and a vast amount of labour in accumulating and arranging this catalogue of compounds, tested or employed at one time or another for the control of insect pests, with the appropriate references to original or review papers and to the patent literature.

The compounds are not arranged alphabetically, and before the catalogue can be used with advantage it is essential that the coding system employed be studied with some care and mastered. This requires a certain amount of knowledge of chemical terminology; but briefly, a code number is assigned to each constituent group of a compound, which is specified by arranging these in consecutive order, beginning at the lowest. Thus D.D.T. is expressed by a number, 855–952–1011, which was turned up quite rapidly, only to find no references to the literature were given; the author, however, explicitly rules out from his survey the better-known insecticides for which review papers and monographs are in abundant supply. It is for the less-known compounds that this record will be of use to the research worker. It is, perhaps, natural that the greater proportion of the references are to papers in American journals and to the bulletins of American research stations, but if this experiment succeeds, doubtless the range will be made wider in future editions.

It is to be regretted that the alphabetical index of the compounds has been relegated to the end of Volume 2, since if insecticides and fungicides deserve separate volumes—which they do—they should each have had their own index. It would not only have made this volume of greater value to those investigators whose knowledge of chemistry might be deficient, but also it might have made the array of facts in the book more rapidly accessible to others.

CENTENARY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

By Dr. F. R. MOULTON
Administrative Secretary

FROM September 13 until September 17 the American Association for the Advancement of Science will hold in Washington, D.C., the centennial celebration of its founding. It was born in Philadelphia, Pennsylvania, on September 20, 1848.

The A.A.A.S. (to use the customary abbreviation of the present time) owes much, particularly in its earlier years, to the pattern set by the British Association for the Advancement of Science, which was organised in 1831. There were still earlier scientific societies in Great Britain and also in the United States, but they were somewhat different in character. The American Philosophical Society of Philadelphia was formally organised by Benjamin Franklin in 1743, and the American Academy of Arts and Sciences was granted a charter in Boston in 1780. The first attempt at establishing a truly national scientific society in America was the launching in 1816, under political sponsorship, of the Columbian Institute for the Promotion of Arts and Sciences. It flashed like a meteor and soon disappeared. Some years later, in 1840, the National Institution for the Promotion of Science was established by an Act of Congress. In 1844 it held a meeting at which John Tyler, then president of the United States, delivered the opening address. Government officials of high rank served as chairmen of the scientific sessions, at which forty-three papers were presented. The Institution never held another meeting.

A few years earlier, in 1837, Dr. John Collins Warren, of Boston, had attended a meeting of the British Association. It impressed him so favourably that upon his return to America he actively began to promote the establishment of a similar society in the United States. The failures of grandiose plans on one hand, and the limitations and weaknesses of small special societies on the other, directed the attention of American men of science to the founding of a scientific society national in scope and embracing all the sciences. This culminated on September 20, 1848, in establishing the American Association for the Advancement of Science, with an initial membership of 461. At the first meeting about thirty papers and oral communications were presented before the "Section of Natural History, etc.", and about as many before the "Section of Physics, etc.", the two subdivisions of the Association at that time.

The first period in the existence of the A.A.A.S. extended from its founding in 1848 until the outbreak of the Civil War between the northern States and the southern States, in 1861. In this interval of fourteen years thirteen meetings were held in different cities in the eastern part of the United States, and one was held in Montreal, Canada. The two original Sections of the Association were gradually divided into more specialized fields. The membership varied from the initial 461 in 1848 to a maximum of 1,004 in 1854.

In 1861 the Civil War broke out, and for five years the A.A.A.S. held no meetings, it elected no presidents or other officers, it issued no publications, and memories of its earlier meetings were dimmed. However, a meeting was held in 1866; but it was not such a meeting as earlier ones had been. The attendance was small, the papers presented were few, and the membership of the Association had declined below that with which it started. The conditions prevailed, generally, for about a decade, or until 1878.

In 1878 the membership of the Association was 962; in 1888 it had increased to 1,964, and it remained at about that level until 1900. Members of the A.A.A.S. were at its beginning and always have been on an annual basis, their dues being paid but once a year. Initially the dues were 1 dollar a year, but increased to 2 dollars in 1851, to 3 dollars in 1874, and finally to 5 dollars in 1920. Beginning with 1900 each member received with his membership a subscription for the weekly journal *Science*, and since 1915 a subscription for either *Science* or *The Scientific Monthly*. At the beginning of this calendar year (1948) the annual membership dues, including a subscription for either of the two journals, became 6.50 dollars a year.

An evolution in the structure and functions of the A.A.A.S. began in the closing decades of the nineteenth century and has continued until the present time. With the progressive specialization in science, the number of sections of the A.A.A.S. steadily increased. As their memberships grew they gave rise to the organisation of special societies—in mathematics, physics, geology, botany, etc. Many of these societies grew rapidly, and their memberships increased to such an extent that it became desirable for them to meet separately in order to obtain adequate accommodations in any American city. In a sense these developments appear to be the reverse of the integrations of science that were achieved when the Association was founded. But integrations of the sciences consist of something more than simultaneous meetings. The interrelations among them have been preserved by maintaining fifteen sections of the A.A.A.S., covering broadly all the principal sciences, the joint programmes of which with one another at the Association's meetings provide the cross-fertilization of ideas so important for vigorous scientific progress.

The outcome of this evolution in the organisation of American science has been a federation of co-operating scientific societies—the A.A.A.S. and its 207 affiliated and associated societies, the combined membership of which now totals several hundred thousands. Each of the 120 affiliated societies has either one or two representatives on the Council of the Association, who together constitute a large majority of the Council; the 87 associated societies are not represented on the Council. The affiliated and associated societies pay no membership fees or dues to the Association or fees for participating in its meetings. The harmony and co-operation of these many scientific societies in advancing science and human welfare present an inspiring example in a contentious and disordered world. It is the purpose of the A.A.A.S. to co-operate much more widely in the future with similar scientific societies in other countries and continents.

Now turning from a brief sketch of the evolution of the plans and ideals of the Association, the statistical story will be resumed, for it is the combination of both the principles and the practices of an organisation that measures its success. Membership statistics of the Association during its first half-

century have been sketched. In 1900 the total membership of the Association was 1,925. In that year the weekly journal *Science*, owned and edited by Dr. J. McKeen Cattell, became the official publication of the Association. By 1908 the membership had become approximately 8,000, and it remained about the same until the close of the First World War, after which it increased rapidly for a decade. It exceeded 15,000 in 1928 and 18,000 in 1938. Now it exceeds 40,000.

There has been a geographical expansion of science, as well as a great increase in the number of men of science, in the United States. In 1916 the Pacific Division of the Association was organised by members of the A.A.A.S. who lived in the great and now populous States on the Pacific coast, about three thousand miles from the large cities in the East and two thousand miles from those in the Middle West, the regions in which meetings were generally held. In 1920 the South-western Division was similarly organised for the convenience of members who live in the south-western States. These Divisions of the Association are wholly autonomous in the election of their officers, the organisation of their annual meetings, and their relations with other scientific societies in their respective areas. The Pacific Division now has more than 4,600 A.A.A.S. members and the South-western Division nearly 800.

Perhaps the most effective way of describing the current policies and activities of the A.A.A.S. is to present a few statistics of the meeting that it held in Chicago during December 26–31, 1947. Although registration at the meetings of the Association has not been generally required, there were 4,940 registrants at the Chicago meeting, each of whom received a general programme. There were, in addition, several thousand persons for whom programmes were not available. As an illustration of the number of men of science at the meeting from a limited field, the official tabulated attendance at the annual "Biologists' Smoker" was 5,575—substantially greater than the total registration from all fields.

There were registrants at the Chicago meeting from every one of the forty-eight States, and also from Alaska and Hawaii. There were seventy-three registrants from Canada, twenty-eight from India and fourteen from China. There were 105 registrants from California, about 2,000 miles westward from Chicago, and 102 from Massachusetts, about 1,000 miles in the opposite direction.

A total of 2,019 papers were on the programme, of which 1,809 were presented orally, 46 consisted of demonstration and informal discussions, and 164 were read by title only. They were distributed among 340 sessions, the maximum number held simultaneously being 41.

It should not be assumed from the large number of men of science attending the "Biologists' Smoker" that the meeting was dominated by biologists or by scientific workers from any other particular field. Nor should it be assumed that the number of men of science was small from the fields in which there are large special scientific societies (the American Chemical Society, for example, or the American Medical Association), which hold their own large meetings quite independently of other scientific societies. At the Chicago meeting of the Association 4,288 registrants recorded their fields of specialization, in part, as follows: fields in which the special societies meet with the A.A.A.S.—zoology (822), biology (498), botany (903); fields in which the special societies hold independent meetings—chemistry (678), physics (296), medical sciences (354), agriculture (176), education (100).

As a consequence of the large attendance at the Association's meetings of specialists from every field of science, it is possible to organise and hold joint symposium programmes on subjects that are not limited by the usual boundaries of the various sciences.

An important feature of the Chicago meeting of the A.A.A.S. last December was the address of Dr. James B. Conant, retiring president of the Association and the president of Harvard University, entitled "The Role of Science in Our Unique Society". There were also ten scholarly addresses by retiring vice-presidents of the Association which in general were surveys or summaries of the fields of science of the Association's sections of which they were the respective chairmen.

In addition to these official programmes, there were seven sessions for special lectures or discussions of various aspects of the role of science in human affairs. Finally, there were fifty symposia on broad sectors of science of high current interest and importance.

As the present officers of the Association look back over the century of progress in organised American science made by their predecessors they have only feelings of gratitude and admiration for the high ideals which moved them and the success which crowned their efforts. As the present officers look with anxiety toward the future they can only say (to paraphrase the closing words of Milton's "Paradise Lost") that all the world is before them and Providence their guide. To paraphrase the opening invocation to "Paradise Lost", they can only say to the Heavenly Muse, what in us is dark, illumine, what is low, raise and support, that we may rise to the height of the great opportunities before us and justify our confidence in the powers of science to improve the lot of man.

ANTIBIOTIC ACTIVITY OF GROWTH-FACTOR ANALOGUES*

THE most striking reactions associated with the growth of micro-organisms are synthetic ones, particularly those concerned with protein synthesis. The synthesis of each compound is a stepwise process, each step being catalysed by an enzyme; if the necessary enzyme is in some way inhibited or has been lost during evolution of the organism, then growth will be slowed down or stopped unless the product of the reaction in which that enzyme was involved is now provided in the external environment. When the synthesis of a compound essential for growth is impossible through natural loss of an enzyme system, then that compound becomes for the organism a 'growth-factor'. By this term it is not meant to imply that the compound in question is not essential for those organisms which do not require it to be present in the external environment; all growth-factors investigated have been shown to be synthesized by a wide variety of organisms which do

* Based on a discussion held at the Royal Society on June 17. There took part in the discussion, which was opened by Sir Paul Fildes, F.R.S., Dr. D. D. Woods, Dr. H. Mellwain, Dr. T. S. Work, Dr. H. N. Rydon and Dr. F. L. Rose; Dr. J. Walker, Dr. A. Albert and Prof. M. Stacey also contributed.

not require them pre-formed and, where these are known, to have the same functions as in the more exacting organisms. Thus it seems justifiable to consider all growth-factors as 'essential metabolites' and to regard the differences in requirements for them as differences in synthetic ability of the organisms investigated. On this basis, interference with the functioning or further utilization of the essential metabolite would produce the same metabolic lesion in those organisms which are able to synthesize it as already exists naturally in those which are not.

The concept of 'substrate competition' was already well established at the time that the mode of action of the sulphonamide drugs was demonstrated. For example, malonate was known to be sufficiently like succinate to be able to form a complex with succinic dehydrogenase, but to be unlike it enough not to go through the stages of dehydrogenation and dissociation. If enough malonate was present, most of the enzyme became involved in formation of the more stable complex; the enzyme was, in fact, inhibited by malonate which was competing with succinate for the attention of the enzyme. This inhibition could be reversed by increasing the concentration of succinate, renewed by adding more malonate, and so on. In just such a way the sulphonamides are held to compete with *p*-aminobenzoic acid, and to prevent its further utilization. Although a certain amount is known about the functions of *p*-aminobenzoic acid, little is known about the receptors with which the competition is concerned Possibly the sulphonamides form complexes with an enzyme or series of enzymes, analogous to the malonate–succinic dehydrogenase complex. Possibly they form complexes with a compound normally associated with *p*-aminobenzoic acid and thus interfere with its function; it has been suggested that reductone may be such a compound, and reductone-*p*-aminobenzoic acid and reductone-sulphonamide complexes have been demonstrated.

Whatever the exact point of attack of the sulphonamides, it was clear that they acted by competing with *p*-aminobenzoic acid, shown to be a growth-factor for a wide variety of organisms, and considered to be an essential metabolite at least for those which are sulphonamide-sensitive. Realization of this, together with the marked chemotherapeutic success of the sulphonamides, stimulated the development of the Fildes–Woods 'rational approach' to chemotherapy. Briefly, it was suggested that analogues of known bacterial growth-factors (or essential metabolites) might be found to bear the same relationship to the parent growth-factor as the sulphonamides bear to *p*-aminobenzoic acid and thus prevent their utilization (or synthesis). Such analogues should prevent or slow bacterial growth and might thus prove to be of use as chemotherapeutic agents.

Several hundred analogues of compounds known to be of importance to the cell have been synthesized and many of them possess the predicted bacteriostatic property *in vitro*. Of the active compounds many are inactive *in vivo*, and others are too toxic to the host to be considered as chemotherapeutic agents. Only certain analogues of pantothenic acid (for example, phenylpantothenone) retain their property of inhibiting growth of the micro-organism *in vivo* and at the same time fulfil the other requirements of a chemotherapeutic drug; had it not been for the development of other antimalarial drugs, phenylpantothenone might to-day be regarded as a practical achievement for the rational approach. Superficially, however, this approach has yielded nothing of chemotherapeutic value; but certain points must be considered before passing judgment. The first concerns the choice of factor. Such is the fundamental similarity of metabolic patterns in all cells that an agent which interferes with a given process in one cell is likely to interfere in a similar way with the metabolism of another cell, independent of species. The repetition of metabolic patterns is seen most clearly in the case of the B group of vitamins. Members of this group have an extremely wide distribution as essential metabolites, and analogues of them have been synthesized and tested in the greatest number. It is not difficult, therefore, to understand the failure of these analogues in chemotherapy, for they interfere with the same fundamental processes in both parasite and host; indeed, several analogues, such as those of aneurin, nicotinic acid and folic acid, have produced in mammals syndromes indistinguishable from those produced by simple dietary deficiencies of the factors concerned.

The relationship between an inhibitory compound and the growth-factor on which it is modelled tends rather to be taken for granted. An analysis of any existing relationship and of the metabolic effects produced by the antagonism is desirable not only for a proper understanding of the mode of action of the analogue (and thereby of the corresponding growth-factor) but also so that the development of more efficient inhibitors should proceed logically. Evidence for the existence of a relationship is of three main types. First, the actual existence of a mutual antagonism has to be demonstrated between growth-factor and analogue. This aspect has been very widely studied and has been the subject of several reviews. Second, even though such an antagonism is established, it should not be assumed that growth inhibition is solely due to it. Specificity of action should be examined in as wide a variety of organisms as possible, and reversal of the inhibition should be limited to the growth-factor in question and to any compounds which may replace it in the growth of organisms requiring it. Finally, the effects produced by the analogue should be just those which are seen as the result of a nutritional deficiency of the growth-factor.

It is desirable also that the exact point of attack of the inhibitor should be investigated. This presents a complex problem, for the various possible processes which can be interfered with are all closely interrelated, and it is not easy to separate primary and secondary effects. Of the three main points at which an analogue can cause a block, the first two, assimilation of the growth-factor and its elaboration into a functioning form, are particularly difficult to separate. No instance of an analogue preventing the assimilation of a growth-factor is known, though little work has been done on this aspect. Most work has been concentrated on the metabolism of the factor once it has entered the cell, and this includes studies on the further elaboration of the growth-factor molecule. As instances, the conversion of *p*-aminobenzoic acid to folic acid and its inhibition by sulphonamides, and the conversion of glutamic acid to glutamine and its inhibition by the sulphoxide of methionine might be cited as examples. In the second example it is also known that the methionine sulphoxide does not interfere with the assimilation of glutamic acid from the external environment but only with its conversion after entry into the cell. The third point at which

analogues may exert their effect is during the actual functioning of the growth-factor, that is, at the point of catalysis. Here again there is very little information available, although the hydrazide of glutamine has been shown to inhibit the breakdown of glutamine to glutamic acid and ammonia, and to be correlated with the inhibition of the growth of streptococci caused by the hydrazide.

To obtain by the rational approach analogues which possess the selective toxicity so necessary for successful chemotherapy, processes must be blocked which are quantitatively more important, or peculiar, to the parasite. It seems unlikely that the sulphonamides are the only analogues of an essential metabolite which fulfil this requirement; with increase in our knowledge of the metabolism of micro-organisms and of the parasite-host relationship, it is probable that more agents will become available. The sulphonamides owe their chemotherapeutic success to the inhibition of a reaction which seems to be absent from animals but essential to micro-organisms (and to members of a number of other species). In several bacteria the sole defect produced by the sulphonamides seems to be an inhibition of the incorporation of *p*-aminobenzoic acid into the folic acid molecule. Animals cannot carry out this synthesis and rely upon a supply of pre-formed folic acid being present in the diet; in other words, the biochemical lesion induced in sensitive organisms by the sulphonamides already exists in the host. Nevertheless, the host may be partially dependent on factors synthesized by its intestinal flora; the effect of sulphonamides on such syntheses may account in part for the toxicity sometimes seen in sulphonamide therapy. Moreover, it is known that much of the folic acid present in animal tissues and fluids is in the form of conjugates, a form not available to the parasite. The position, then, is that formation of folic acid by the host-dwelling parasite is blocked from below by the sulphonamides and from above by natural lack of the enzymes necessary for releasing folic acid from its conjugates; the host, on the other hand, relies on a supply of pre-formed folic acid and converts it largely to a form not available to the parasite.

A similar situation may explain the partial success of analogues of pantothenic acid, for this factor is known to exist in animals in the form of co-enzyme A, a more complex molecule. Although micro-organisms carry out a similar elaboration of pantothenic acid, they do not seem to be able—through inability to absorb it or through slight differences in structure—to make use of animal co-enzyme A to supply their own requirements.

The sulphonamides, and possibly also analogues of pantothenic acid, thus provide examples of compounds which interfere with reactions peculiar to the parasite and exploit qualitative differences in metabolism. Further inhibitors of this type, as already stated, will develop logically from the finding of further synthetic reactions of the parasite. A hopeful field, already opening out, is associated with peptide metabolism. Species specificity of structure is nowhere so marked as in the proteins, and it is in their synthesis that species-specific biochemical reactions are most likely to be found. For example, a certain amino-acid sequence in a simple peptide might be harmless or even favourable to one species, but toxic, through slight differences in sequence from normal peptides of that species, to another. It is interesting to note in this connexion that several of the naturally occurring antibiotics are peptides. One of them, lycomarasmin, is the tripeptide seryl-glycyl-aspartic acid. Its toxicity towards *Lactobacillus casei* and the tomato plant (it is the active agent of the tomato-wilt fungus *Fusarium lycopersici*) is annulled competitively by strepogenin, also a peptide and a growth-factor for a number of organisms. The observed biological relationship suggested a possible chemical relationship (using the rational approach 'in reverse'), and the synthesis of seryl-glycyl-glutamic acid yielded a compound with some strepogenin activity, both as growth-factor and as antagonist to lycomarasmin. On this and other grounds, it is not impossible that other natural antibiotics may turn out to be analogues of essential metabolites; there is already some evidence for this in the case of streptomycin.

For successful chemotherapy, though, it may not be necessary to restrict attention to reactions which are peculiar to the parasite. The temporary blocking of processes quantitatively more important to the parasite than to the host might prevent growth of the former for long enough to allow the natural defences of the host to overcome the invader without seriously damaging the host.

Another point to be considered is that, although the rational approach has yielded little in the way of chemotherapeutic agents, it has provided metabolic tools of the greatest value in investigating the actual function of the growth-factors. As they inhibit specifically the synthesis or utilization of the growth-factor, they provide a chance of tracing the primary effect of that factor. For example, γ-3,4-urylene-cyclohexylbutyric acid, an analogue of biotin, inhibits the growth of *Lactobacillus arabinosus*, and this inhibition is reversed competitively by biotin. The amount of biotin required to overcome the inhibition by a given concentration of the analogue is decreased ten-fold if oxaloacetic acid is present. This indicates that one function of biotin is in the synthesis of oxaloacetic acid.

Similarly, use of the sulphonamides has contributed greatly to knowledge of the function of *p*-aminobenzoic acid, which is involved in the synthesis of folic acid, purines, thymine, methionine, lysine, serine and possibly valine. Inhibition of the synthesis of folic acid by sulphonamides has been demonstrated in a direct way. Further use of the analogues in such researches may well reveal points suitable for chemotherapeutic interference.

When a suitable growth-factor or essential metabolite has been selected for modification, it has yet to be decided what changes are to be wrought in the original molecule to produce an efficient inhibitor. So far it has only been possible to predict in a very general way whether a given analogue is likely to prove inhibitory. Trial and error may be costly of time and fail completely to give an active compound, for it is not enough to go on simple pictorial analogy. It is not enough because an analogue may look like a metabolite and yet lack the chemical groupings necessary for combination with, for example, an enzyme; and because it leads to over-emphasis of the geometry and under-emphasis of the chemistry of the molecule. At the same time, pictorial analogy is too much, for it leads to possible overloading of the analogue with unnecessary groups which have nothing to do with the attachment of it or the metabolite to the enzyme. In order to model inhibitors more successfully on essential metabolites two things at least must be known: first, the structure of the metabolite to be imitated; and secondly,

the precise way in which it associates with the bacterial enzyme to which it is related as substrate, co-enzyme or product.

Many attempts have been made to explain the action of the antimalarial drugs on the basis of their being metabolite analogues, and there is much evidence, both chemical and biological, that quinine, 'Mepacrine' and 'Pamaquin' and possibly also the more recent anilinopyrimidines act as inhibitors of reactions involving riboflavin, at any rate in bacteria. As pointed out above, the fact that a substance chemically related to a growth-factor can compete with that growth-factor does not of necessity imply that an associated growth inhibition can be correlated with the metabolite analogy. Thus the final biological proof that these antimalarials are active solely because tinthey erfere with the action of flavin derivatives has yet to be provided. The newer and highly successful 'Paludrine' was developed by logical chemical steps from 'Mepacrine'; yet in no system has it been shown as a riboflavin competitor. There is no biological evidence for the mode of action of 'Paludrine', but it has been suggested that either by chelating a metal or by nature of the intrinsic size and shape of its cation (there is evidence that it exists as a pseudo-triazole involving a hydrogen-bond) it may possess a structure similar enough to that of the porphyrins to interfere with their metabolism. It is also possible that, as also in the case of the natural antibiotics, discovery of the mode of action of 'Paludrine' may disclose a new essential metabolite.

Had oxine (8-hydroxyquinoline) not already been well known as a chelating agent, the strong antibacterial activity of it and its derivatives might have been difficult to explain, particularly as the lethal action against Gram-positive organisms is far more powerful at low concentrations ($10^{-6}M$) than at higher ones ($3 \times 10^{-3}M$). The hypothesis advanced to explain their action against Gram-positive organisms, and backed by much experimental evidence, is this: at low concentrations the oxine chelates cobalt (cobalt is the only metal which will reverse the inhibition) and thus exposes the bacteria to the action of a second metal which catalyses the oxidation of a chemical group protected by the cobalt. Stronger solutions of oxine protect the organism by removing the injurious metal as well. The second metal has been identified as ferrous iron, and it seems that in the presence of lethal concentrations of oxine the organisms actually die of iron poisoning. Although oxine and its derivatives are not growth-factor analogues, their action is to prevent the normal functioning of essential ions, and a consideration of them is germane to any discussion on chemotherapy. Their mode of action, a disturbance of an existing balance with lethal results to the micro-organism, is worth considering in connexion with other antibacterial agents.

So the biochemist and the chemist, by producing changes in the structure of compounds already known to show a selective toxicity towards the parasite, may produce more and more efficient chemotherapeutic agents. But inevitably, as more is learned of the comparative biochemistry and physiology of micro-organism and potential host, and of those synthetic processes which are more peculiar to the micro-organism, the biologist will seek the closer co-operation of the chemist so that together they may plan, synthesize and test new chemotherapeutic agents.

PARTITION CHROMATOGRAPHY ON PAPER, ITS SCOPE AND APPLICATION

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WITHIN the last twenty years, chromatography has become increasingly important as an analytical tool. The purpose of this article is to review the uses of partition chromatography on paper, which, since its inception four years ago[1], has had a wide application and which promises to become as well established as the older forms of chromatography. It should be emphasized, however, that, as mixtures, especially from biological sources, may be very complex, preliminary separations[2–5] may often be necessary before paper chromatography can be used to the best possible advantage. For recent developments in all types of chromatography, the reader is referred to a number of articles indicated in footnotes 6–9.

Partition chromatography was first developed by Martin and Synge[10] at the laboratories of the Wool Industries Research Association. In this type of chromatogram, separations are achieved because of the differences in partition coefficients between aqueous and non-aqueous phases of the components of a mixture. Using silica gel as the supporting medium for the aqueous phase and eluting with certain water-saturated immiscible organic liquids, separation and estimation of a number of acetyl-amino-acids were effected. This provides a relatively simple and valuable method for the quantitative analysis of some half-a-dozen amino-acids in protein hydrolysates, after acetylation. With the free amino-acids themselves, it was found that owing to their strong adsorption by the silica gel, separations could not be achieved. However, cellulose, in the form of filter paper, was found to be suitable as the stationary support. In this method, a filter paper strip, carrying a mixture of amino-acids (a few micrograms of each) near its upper end, is hung from a trough containing water-saturated solvent (for example, *n*-butanol, phenol, *s*-collidine), the whole system being in an atmosphere saturated with respect to solvent and water vapours. The solvent syphons down the strip, and after a suitable time the amino-acids are revealed by drying the paper and spraying with a solution of ninhydrin and then gently heating. (A simplification of this method—'ascending' chromatography—has been recently reported[11].) It was found that the movement of amino-acids corresponded fairly closely with that calculated from their partition coefficients, thus demonstrating that the cellulose, as in the case of silica gel, acts as an inert support for the aqueous phase. This type of chromatogram is of value because of its simplicity and because many analyses may be carried out on one paper strip, using only very small amounts of material. An early application[12] was to show that *nor*-leucine was not present in spinal cord, as had been originally supposed.

No single solvent has been found which will separate all the common amino-acids on a paper strip; but a more complete separation can be obtained in the 'two-dimensional' technique in which the mixture applied near one corner of a filter paper sheet is chromatographed in one direction with one solvent and then in a direction at right angles with another

solvent. The components are thus distributed over the area of a sheet, and by choosing two solvents with different properties, such as *s*-collidine for one direction and phenol for the other, most of the common amino-acids are separated, only $\frac{1}{4}$–$\frac{1}{2}$ mgm. of protein being required, and all may be separated by additional one-dimensional chromatograms in other solvent systems. On a two-dimensional sheet, the amino-acids occupy characteristic positions, depending on the solvents used, and 'maps'[11,14–17] have been published showing the positions of ninhydrin colouring constituents of biological mixtures.

Ninhydrin has been found to be the best general indicator for the amino-acids as it is very sensitive and little affected by traces of solvents left on the paper after drying. However, as is well known, it is not specific for the amino-acids; any substance having both free amino- and free carboxyl-groups, such as peptides and non-α-amino-acids, gives colours, while less intense colours are given by nitrogen bases, including amino-acid esters. Though not so sensitive as ninhydrin, β-naphthaquinone sulphonic acid (Folin's reagent) is a useful general indicator, and amino-acids and peptides can be located by their weak fluorescence in ultra-violet light[18]. A number of more specific indicators are available, though, in some cases, thorough removal of solvent from the paper may be necessary, prior to their use. Diazotized sulphanilic acid is an even more sensitive reagent for histidine than ninhydrin. For tryptophan, *p*-dimethylaminobenzaldehyde in acid solution is useful, and with reduced tryptophan, 2 : 4-dinitrophenylpyridinium chloride gives a strong cerise colour. Other useful reagents are potassium iodoplatinate for amino-acids which carry the thio-ether link (for example, methionine and lanthionine), and periodic acid in conjunction with Nessler's solution for the aliphatic hydroxy-amino-acids. The ingenious use of *D*-amino-acid oxidase by Synge (unpublished) for revealing configuration has been applied by Jones[19] to show that the leucine residues of aerosporin have the *D*-form. Dent (private communication) has developed a method for distinguishing between α- and non-α-amino-acids, by removal of the former as their copper complexes; and the latter, which do not readily form copper complexes, are revealed by ninhydrin.

An early application of the two-dimensional paper chromatogram was by Edman[13], who demonstrated the amino-acids in hypertensin hydrolysates. Modifications of amino-acid residues in a protein after chemical treatment can often be easily observed. Thus, small amounts of lanthionine and cysteic acid have been demonstrated to be present in hydrolysates of wool tips[14], showing that the action of weather and light have modified some of the combined cystine. Cysteic acid has been shown to be present in hydrolysates of wool which had received various oxidizing treatments[3,14], and some destruction of proline and tyrosine has been observed after chlorination of wool. A not unimportant use of paper chromatography is as a control for synthesis[20] and separations[3,21], and to test the purity of substances. Mention should be made of its growing use as a control for various industrial processes involving utilization of amino-acid and peptide mixtures, such as in penicillin and streptomycin production; but, so far, little has been published in this connexion.

New or unsuspected constituents can be revealed and it is often possible, from its position on the chromatogram, to make a reasonable guess as to the nature of a new substance. For example, Consden, Gordon and Martin (unpublished) observed what was considered to be a weakly basic substance in elastin hydrolysates, and this was confirmed by subsequent electrodialytic experiments. Jones[22] demonstrated the presence of α-γ-diaminobutyric acid in aerosporin, and Borsook *et al.*[23] showed that lysine was metabolized by guinea pig liver to α-aminoadipic acid. Amino-acids, other than the α-variety, and amino-acids not common in animal proteins appear to be widely distributed in plant and bacterial extracts such as α- and γ-amino-butyric acids[15,16]. Indeed, plant extracts offer a vast field for paper chromatography, and already the first reported applications[15,16] have yielded much valuable information, both as regards new constituents and metabolism. The non-protein nitrogen fraction of plants may sometimes contain only relatively few ninhydrin colouring constituents. For example, Consden and Gordon (unpublished) found that an aqueous extract of tea contains only three such substances in strength, namely, aspartic and glutamic acids, and the third, now under investigation, is believed to be a mono ester of glutamic acid. There are obvious applications of paper chromatography in the study of plant extracts to agriculture and animal nutrition.

In the medical field the usefulness of paper chromatography has been shown by Dent[25] in studies of pathological urines and in determining the fate of proteins after digestion[26]; and there is a great potential use for radioactive isotopes, as is evident from metabolic studies with radioiodine[27], radiocarbon[28], and radiosulphur[29].

There is a fast-growing list of substances other than amino-acids to which paper chromatography is applicable, and which can only be referred to briefly here. An important field was opened up by Partridge[30,30], with the sugars, and the introduction of specific indicators[31] should prove to be particularly useful. Another potentially important field, especially for the study of prosthetic groups, are the flavines[32] and purines[33]. Other substances reported to be separable on paper chromatograms are anthocyanine pigments from petals[34], organic acids[35], adrenalin and related substances[36], creatine and creatinine[37], penicillins[38] and vegetable tannins[39].

Extension to quantitative analysis has enhanced the usefulness of paper chromatography. For many purposes, a rough estimate of a given amino-acid may be usefully made by comparison of the intensity of its ninhydrin spot with that of known amounts of the same amino-acid chromatographed under the same conditions[3,40]. This is clearly capable of industrial application. A refinement of this visual comparison method for both sugars and amino-acids has been reported[41]. The ninhydrin colours themselves have been used for estimations after extraction from the paper[42]. Extraction of amino-acids as their copper complexes, followed by polarographic determination of the copper, has been described[42,43]. This method was used to estimate the five amino-acids produced after hydrolysis of gramicidin S[42]. Alternatively, the copper can be estimated colorimetrically[44], and this method was used by Jones to show that the proportion of leucine to threonine in hydrolysates of aerosporin is 1 : 3 [22]. An interesting isotope dilution method has been described[44a] in which amino-acids are first converted to *p*-iodobenzenesulphonyl derivatives containing radio-active iodine or sulphur and then estimated on paper chromatograms by counting. Quantitative analysis on paper chromato-

grams of substances other than amino-acids have been devised, notably for sugars and their derivatives[45,46].

Perhaps the most important application of paper chromatography is to elucidate the sequence of amino-acid residues in proteins and polypeptides. This is a problem of fundamental importance, but has long been unsolved because of the lack of methods for handling complicated mixtures of peptides which result from partial hydrolysis; and, in fact, very few peptides have been isolated and identified[47] by the traditional chemical methods. However, simple peptides behave on paper chromatograms as satisfactorily as amino-acids, and techniques have been devised[4] to separate and identify lower peptides in complex mixtures. The sequence of the amino-acid residues of gramicidin-S was thus established[48] as -(α-valyl) - ornithyl - leucyl - phenylalanyl - prolyl-. Tyrocidin appears to incorporate the sequence -valyl-ornithyl-leucyl- and probably the sequence -aspartyl-glutamyl-tyrosyl- in its structure (Consden, Gordon and Martin, unpublished). There would appear to be a promising field for similar investigations of other polypeptides, the list of which is rapidly growing, consisting of residues of a few varieties of amino-acid or having molecular weights intermediate between simple molecules and proteins.

With the proteins themselves, the mixture arising from partial hydrolysis is likely to be vastly more complex, and it is too much to expect that the structure of a protein could be pieced together from the peptides identified. So far as I am aware, wool is the only protein which has been examined in this way, and preliminary reports have been given by Martin[49] of the identification of nineteen dipeptides of aspartic and glutamic acids[50] and of a number of peptides from the less completely investigated neutral and basic fractions of partial hydrolysates of wool[51]. One conclusion from these studies is that a substantial proportion of the glutamic acid is linked with itself in the wool polypeptide chain. Recently, Consden and Gordon[5] have described techniques for identifying peptides of cystine, and it can be concluded that, in wool, cystine is linked *via* one of its amino-groups and *via* one of its carboxyl-groups to residues of glutamic acid and to residues of most of the neutral amino-acids and that a substantial proportion of proline residues, if not next to, are not far from, cystine residues. The possibility of identifying a large number of peptides in partial hydrolysis mixtures should be a big step forward in our knowledge of protein structure.

It has not been possible to deal adequately here with all aspects of paper chromatography, especially pending publication of the many important developments which are now rapidly taking place. However, enough has been indicated to justify the confident expectation that, before long, this technique will be in common use in many laboratories.

Grateful acknowledgment is made for useful information from Drs. C. E. Dent and A. H. Gordon and to the Director of Research, Wool Industries Research Association, for his interest and advice.

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OBITUARIES

Mr. S. G. Brown, F.R.S.

SYDNEY GEORGE BROWN died on August 6 at Sidmouth, where he went to live on his retirement. He was seventy-five years of age.

Born in Chicago in 1873, his father having gone there to live, he was brought to Great Britain at an early age. He was educated at Harrogate College and University College, London. On leaving college he served as an apprentice in the works of the late Col. Crompton at Chelmsford, where he was principally engaged on calculations and design of dynamos and motors. In 1908 he married Alice Stower, niece of Prof. John Perry, whose close friendship he enjoyed until the time of the latter's death.

It is by his numerous inventions that Mr. Brown became famous. He claimed to have taken out about a thousand patents, commencing when sixteen

with a home-made phonograph. In 1899, when only twenty-six years of age, he produced the drum cable relay used in submarine telegraphy. This was followed by the magnetic shunt and other devices connected with duplex working over long-distance cables. Also at this time, with Sir Henry Hozier, he demonstrated a system of directional beam wireless using a parabolic reflector of wire. Signals were transmitted for over a mile between a coastguard station and a lighthouse at Beachy Head. These distances were later increased. This patent was dated 1899.

Finding difficulties in getting his inventions manufactured, he opened in 1910 his own workshops near Liverpool Street, London. After two moves to obtain more space he decided in 1915 to have his own factory built, for which purpose he purchased a large site in Acton, London.

In 1910 he patented his reed type telephone earpiece, by means of which wireless messages could be read when otherwise inaudible. They were adopted as standard by the Royal Navy. He worked on electrical aids for the deaf and was possibly the first to demonstrate bone conduction for hearing. In 1909 he perfected various types of relays for the purpose of amplifying feeble currents both for use in wireless and telephony. This was in the days before the introduction of the thermionic valve. Early in 1914 one of these, the microphone relay, was accepted by the Royal Air Force for use in aeroplanes. By its use wireless messages could be received during flight. The same relays were used by the Admiralty for extending the range of signalling at sea.

Mr. Brown conducted considerable research on rare metals for contact purposes. At the request of the Admiralty he designed the electro megaphone for loudspeaking on warships. One form of this instrument is used on the London Underground Railways for speech between guard and driver. The late Admiral Lord Fisher personally wrote thanking Mr. Brown for his work on relays for detonating mines, using the current from a selenium cell operated by the rays of a searchlight.

The greatest of Mr. Brown's inventions, however, and the one that he himself ranked as his highest achievement, was his gyroscopic compass. The two principal features are the vertical axis and the liquid ballistic. By the first, friction is reduced to a minimum by raising and lowering the whole of the north-seeking parts, including the gyro wheel, at more than a hundred times a minute, using a column of oil, pump-operated. To overcome quadrantal error, common to all gyro compasses, he replaced the solid weight used to precess the compass by a liquid which was free to flow from side to side of the wheel during the rolling of the ship. To work in conjunction with his compass he designed an automatic helmsman which makes it possible to steer a course at sea direct from the compass. He further made a multiple repeater for the ease of steering by hand, also a recorder on which the course of the ship can be plotted on a moving chart. His last invention was a gunnery control compass. This demanded an extreme accuracy at sea only previously associated with a laboratory compass working in a stationary position on land. Such a compass was completed and had passed Admiralty requirements when its adoption was delayed owing to the Second World War making its application impracticable.

With the introduction of broadcasting, Mr. Brown turned his mind to mass production, thousands of pairs of headphones being produced daily. He gave the name to the loudspeaker. While he produced many types fitted with horns he foresaw the development of the large cone diaphragm back in 1910, when he referred to its possibilities in his receiver specification.

During the First World War, Mr. Brown served on the Research Committee for the Detection of Enemy Submarines, the Inventions Board and the Admiralty Ordnance Council. He was elected a fellow of the Royal Society in 1916. In March, 1909, he read a paper before the Royal Institution on "Submarine Telegraphy", and in 1920 one on the "Gyroscopic Compass".

Apart from his activities with the Company that bears his name, he founded and was chairman of the Telegraph Condenser Company.

With all his inventions Mr. Brown acted as his own designer. He was an accomplished engineer capable of giving advice in any department of his works. He was held in great respect by his staff, with whose assistance he earned a great reputation for the high quality of all his work.

H. PASMORE

Prof. Marcel Brillouin

THE Nestor of French physics, Marcel Brillouin, formerly professor of physics in the Collège de France, died on June 16 at the age of ninety-four. He belonged to a generation of men of science who could not only master the whole realm of their subject but also make important original contributions to almost every branch of it. As a result they were able to present that subject to their students in a most perfect form, thus providing them with a solid foundation for their own future activities in this field. Prof. Brillouin's lecture courses at the Collège de France provide an outstanding example of this almost extinct art, and many of them have been published in book form, like the well-known "Leçons sur la viscosité des liquides et des gaz".

Like many great physicists, he started as a mathematician at the École normale; but his natural inclination soon diverted him first to mechanics and later to physics as a whole. Thus he acquired skill in the use of mathematics as well as in the handling of apparatus which enabled him to carry out investigations requiring refined experimental and mathematical techniques at the same time, which is so rarely found in physicists of the present generation.

Only a brief indication of Brillouin's most important research subjects can be given here. In hydrodynamics he did fundamental work on the theory of discontinuity surfaces in liquid flow and the formation of vortices on similar lines to Helmholtz, and in aerodynamics he developed a theory of the dispersion of sound. In thermodynamics he devoted himself to the study of permanent deformations of solids and to the specific heat of black body radiation, and he derived the proportionality of this quantity with the third power of absolute temperature. The kinetic theory of matter was enriched by Brillouin's contributions to the theory of diffusion and viscosity in gases and liquids, and he also took part in the once topical controversy on the apparent contradiction in statistical mechanics between the reversibility of the laws of dynamics and the irreversibility of those of thermodynamics. He was very much interested in geophysics as well, and he con-

tributed to this branch of applied physics by papers on the circulation of the atmosphere, the formation of rain, the theory of the tides, etc. An outstanding piece of research in this field consisted in a series of precision measurements of gravity within the Simplon tunnel aiming at a determination of the shape of the 'geoid'. Although naturally his main activity was in the domain of 'classical' physics, he was nevertheless actively interested in the theory of relativity and in quantum theory, where he made an early attempt to give a representation of quantum phenomena in terms of a continuum theory.

It was a source of great satisfaction to Brillouin that the successor to his chair was one of his own sons, Léon Brillouin, who, carrying further the work of his father, has become one of our leading theoretical physicists.

R. FÜRTH

Prof. Beatrice Edgell

THE death of Prof. Beatrice Edgell, professor emeritus in the University of London, takes from us one of the significant figures in the development of British psychology. Born in 1871, she was of the same generation as McDougall and C. S. Myers, with whom she collaborated in the pioneer work of the British Psychological Society and with whom she helped to establish the traditions on which the study of psychology is still based in British universities. Trained first in philosophy at the University College of Wales, Aberystwyth, she turned to experimental psychology and studied at Würzburg, where the use of experimental method was being developed in the study of the processes of thought and judgment. Throughout her life she combined her interests in philosophy and in experimental psychology, though with a special leaning to the latter, and from 1897 until 1933 she was head of the Department of Philosophy and Psychology at Bedford College in the University of London.

At a time when in many universities psychology was at best a subordinate partner of philosophy, her position as professor of psychology in charge of both subjects was unusual. The laboratory she established bears witness to her concern for exact and objective experimental method aided by the best material equipment then available. Her chief publications ("Theories of Memory" (1924), "Mental Life" (1926) and "Ethical Problems" (1929)) indicate the two sides of her interest, as does the fact of her contributing both to psychological journals and to the *Proceedings of the Aristotelian Society*. Her example and influence thus aided the development of psychology in Britain as an independent experimental science which still retained the stabilizing effect of philosophical discipline. Her psychological interests centred largely on the cognitive aspect of mental experience, especially memory and perception, and she also paid particular attention to the experimental approach to aesthetics. As a teacher, however, she was stimulating over a wider range. "Ethical Problems" was written specially with the view of helping nurses, and her text-book, "Mental Life", was intended for students preparing for social work. Precise of mind and emphatic of utterance she was an excellent teacher, and she is held in affectionate respect by a large number of former students, many of whom are now engaged in psychological work applied to industry, education and various branches of social work.

In her retirement Prof. Edgell still occupied herself with psychology, including its newer developments. She was recently, for example, using the Rorschach test with critical appreciation. She continued to help students, and to take an active interest in the British Psychological Society, of which she was a past president and honorary fellow. During the War she wrote a history of the Society, part of which she read at the annual meeting of the Society in 1946. This was the first occasion on which many of her younger colleagues had met her, and they will remember her as they saw her then, frail, alert and indomitable.

NEWS and VIEWS

Psychological Medicine in Glasgow: Prof. T. Ferguson Rodger

DR. T. FERGUSON RODGER has been chosen as the first occupant of the newly founded chair of psychological medicine in the University of Glasgow. Dr. Rodger graduated in science and medicine at Glasgow in 1927–29 and holds the diploma in psychological medicine of the University of London. During 1931–32 he worked at Johns Hopkins University, where he was a pupil of Adolf Meyer. From 1933 until 1939 he was senior assistant at Glasgow Royal Mental Hospital (Gartnavel), and an assistant to the lecturer in psychiatry in the University. Throughout the War he served in the Royal Army Medical Corps as consulting psychiatrist at Headquarters, Land Forces, South-East Asia, and at General Headquarters, India. Latterly, he has been a commissioner of the General Board of Control (which functions under the Lunacy, Mental Treatment and Mental Deficiency Acts). Dr. Rodger has specialized in psychosomatic medicine. He was responsible for research into the methods of selecting officers for the army. He has also published work on fibrositis and on night-blindness.

Pathology in Glasgow: Prof. G. L. Montgomery

GEORGE LIGHTBODY MONTGOMERY has been appointed to the St. Mungo-Notman chair of pathology (associated with the Royal Infirmary, Glasgow) in succession to Prof. John W. S. Blacklock, who has moved to St. Bartholomew's Hospital, London. Prof. Montgomery graduated at Glasgow (M.B., Ch.B., 1928; M.D., 1946), and also holds the Ph.D. degree of the University of St. Andrews (1936). After holding appointments at Glasgow Royal Infirmary, in 1931 he became lecturer in clinical pathology at St. Andrews and assistant pathologist at Dundee Royal Infirmary. Since 1937 he has been Gardiner research lecturer in the pathology of disease in infancy and childhood in the University of Glasgow, and pathologist at the Royal Hospital for Sick Children, Yorkhill. During almost the whole of the

War he served on the Directorate of Pathology at home, in the Central Mediterranean and in South-East Asia. His researches include work on the renal function in various morbid states, on diseases of childhood (with special reference to non-tubercular infections of the lung), and on the healing of lung injuries. He has recently taken part in the trials of streptomycin carried out by the Medical Research Council.

Victor Meyer (1848–97)

Among the many eminent German chemists of the latter half of last century, none enjoyed a higher reputation than Victor Meyer, who entered the University of Heidelberg in 1865 at the age of seventeen and, twenty-four years later, was chosen to succeed his old master Bunsen in the chair of chemistry there. Meyer was born at Berlin on September 8, 1848, being the son of a Jewish calico manufacturer. His home influences had tended towards the literary and artistic rather than the scientific, and Meyer, it is said, wished to become an actor, for which he had all the natural gifts. At Heidelberg, however, he came under the spell of Kopp, Kirchhoff, Helmholtz and Bunsen, and after a time became assistant to the last. From Heidelberg he went to Berlin to work under Baeyer, and successively held posts at Stuttgart, Zurich and Göttingen, before returning to his *alma mater*. With a fine voice, handsome presence and impressive manner, he became known as one of the best lecturers in Germany. With his other gifts he combined a passion for work, and was responsible for some three hundred memoirs. His most important investigations are referred to in the Memorial Lecture on Meyer delivered to the Chemical Society on February 8, 1900, by Sir Edward Thorpe, who had known him for thirty years. Unfortunately, his great mental activity brought on insomnia and he had several spells of ill-health. His death took place on August 8, 1897, when he was but forty-eight years of age. He had received many honours from scientific societies, and among these was a Royal Medal from the Royal Society awarded him two years after he had succeeded Bunsen.

Dedication of Private Woodlands

In the Forestry Commission Booklet No. 2 (H.M. Stationery Office, London, 1948) the purpose of the scheme for the dedication of private woodlands is explained. This purpose is to encourage the application of systematic management to private woodlands, become necessary, it is said, in the interests of national security because the reserves of standing timber have been greatly depleted during and since the War; and it might be added are still suffering from more or less crude over-felling, especially in the hardwood areas. Under the scheme the owner undertakes to use the land in such a way that timber production is the main object; to work to a plan to be approved by the Forestry Commission; to employ skilled supervision, and to keep adequate accounts. The object of the scheme is to ensure that replanting or regeneration of woodlands cut during the War shall proceed with continuity and rapidity, that this work in its young stages must be looked after until the young woods are established and, it is to be proposed, after that stage has been reached. Owners must make up their minds as to whether they are prepared to work the scheme; if they agree, they will receive State financial assistance. If the owner is unwilling to join the scheme or keep his woodland areas in proper order, the State will acquire them. Finally, some system of control of the sylviculture of private woodlands is deemed necessary.

To give effect to the scheme a deed of covenant in England and Wales and an agreement in Scotland will be entered into by which both the State and the owner undertake respective obligations as already mentioned. The Forestry Commission, as the agent of Government, will undertake to provide financial assistance to the owner on one of these bases at the owner's option: (1) To repay to the owner 25 per cent of the approved net annual expenditure on a dedicated woodland by way of loans which are described in the pamphlet. (2) To make payment to the owner as follows: (*a*) a planting grant of £10 per annum for every acre planted or replanted, softwood or hardwood, after date of dedication; (*b*) loans in addition to (*a*) on terms to be settled according to individual circumstances, the terms being given in the pamphlet; (*c*) a maintenance grant for fifteen years of 3*s*. 4*d*. per acre per annum on every acre dedicated that is planted properly and maintained; (*d*) a maintenance grant for fifteen years of 3*s*. 4*d*. per acre per annum from the date of dedication, on all productive woodlands other than new plantations covered already by (*c*) and (*d*). These grants will be reviewed and revised as may be necessary after five years from 1946–47 on the basis of ascertained costs. Dedication will run with the land and will not be affected by change in ownership.

New German Hydrographic Journal

With the first issue of the *Deutsche Hydrographische Zeitschrift* (1, No. 1, January, 1948), to the forthcoming appearance of which reference was made in *Nature* of August 16, 1947, p. 219, the publication of post-war articles by German oceanographers and other marine scientists and technicians commences. The first paper, by K. Kalle, deals with the problem of marine production and reviews research material and methods of investigation. Kalle compares the probable amount of marine production with the yields known from continental soils of the temperate zones. W. Hansen in the second article gives a general mathematical treatment of the oscillations of inertia in open and land-locked seas. The old nautical problem of the dip of the horizon is attacked once more theoretically, by H. Chr. Freiesleben. He derives a formula which, in order to be strictly employed, demands measurements of the air-temperature at the horizon immediately above the sea-surface. Another short but interesting contribution, by F. Errulat, describes a series of measurements of the earth-magnetic field on the Dacia Bank (between Madeira and Morocco); he concludes that the Bank has a core of eruptive rocks. The field of nautical technique is represented by a description of a direction-holder named "Polkreisel", by P. Christoph. Moreover, there is an article on the German Hydrographic Institute, its origin, its tasks, and its organisation by the director, Dr. Böhnecke, and finally there are obituary notes on several notable German scientists who had worked on nautical science and on oceanography. In the next issue (No. 2/3) of the *Zeitschrift*, which was expected to be distributed in the beginning of August 1948, there is to be (with other papers) articles on the bottom geology of the southern and middle Baltic, on a fundamental geodetic problem in sea-surveying, on magnetic storms, and on resonance oscillations of bights and the mouth correction for seiches.

Trade Unions in Industry

As part of a general production drive, the Trades Union Congress is inviting trade unionists to extend their knowledge of management in industry. Through its publicity organ *Industrial News*, the Congress has announced that it is co-operating with the National Institute of Industrial Psychology, the British Institute of Management, the Government Committee on Industrial Productivity and the Administrative Staff College in seeking ways to make workshops more happy and efficient places. Experiments are to be carried out on the problems of the effects of boredom in industry, the means of minimizing labour turnover and the training of new employees. The Trades Union Congress is asking members of trade unions to co-operate with these organisations by seeking goodwill for their officers at places suitable for experiment.

Cultivation of Root Vegetables

Bulletin No. 120 of the Ministry of Agriculture and Fisheries (H.M. Stationery Office. 9*d*. net) deals with all phases of the commercial cultivation of carrots, beetroot, parsnips, turnips, swedes and other minor root crops. A new revision (August 1947) of the third edition has recently appeared, and brings the subject-matter up to date. The most modern additions deal with row-crop cultivation, irrigation, and the control of weeds.

Precession of an Unsymmetrical Top

It has been known since the time of Lagrange's "Mécanique Analytique" (1788) that a rigid body smoothly pivoted at one of its points O and symmetrical about an axis passing through O can have steady motions of precession in which the axis of symmetry rotates uniformly about the vertical while the solid itself rotates uniformly about the axis of symmetry; but it has been generally supposed that there is no corresponding result if the body is unsymmetrical. However, G. Grioli (*Annali di Mathematica*, **26**, 1; 1947, and *Rendiconti dell' Accademia Nazionale dei Lincei*, **4**, 420; 1948) has shown that under certain conditions we can have steady precession of an unsymmetrical body about a non-vertical axis. If G is the centre of mass, it is necessary that OG should be perpendicular to one of the two circular sections of the momental ellipsoid at G, and that the axis of precession should be inclined to the vertical at a definite angle which can be calculated from the same momental ellipsoid. If these conditions are satisfied, there is a doubly infinite set of motions in which OG is perpendicular to the axis of precession, and the solid rotates uniformly about OG in the same time as OG rotates uniformly about the non-vertical axis of precession.

Geotectonic Map of North-west Germany

Last year the first German publication on scientific geology since the War was issued by the Reichsamt der Bodenforschung, Hanover, namely, a general geotectonic map of north-west Germany, scale 1 : 100,000 (15 sheets, 200 marks). This map comprises all wells and geological as well as geophysical results from 1934 up to 1945. The new map is supplemented by formation data, stratigraphic symbols, profiles, surface contour lines, data of the depths, and geophysical data. Moreover, there is attached a general map, scale 1 : 1,000,000, of the structures and two hundred salt domes in this area. A volume of annotations of the map is projected.

Society for Visiting Scientists

The Society for Visiting Scientists (5 Old Burlington Street, London, W.1) has been able to extend its facilities and membership for scientific workers resident in the United Kingdom. The number of such members is no longer limited, and applications for membership from scientific workers interested in the Society's aims will be welcomed by the Executive Committee. Applicants should apply to the Assistant Secretary, mentioning one or more members of the Society who would be willing to be their sponsors. The subscription for members resident in the United Kingdom is three guineas per annum, with an entrance fee of one guinea. Visiting scientists from overseas are charged an entrance fee of five shillings only, and pay an annual subscription only if they reside in the United Kingdom for more than six months. The Society now has more than 1,300 members, about 1,170 of whom are overseas. In addition to the opportunity of meeting visiting scientists, and thus furthering international contact and friendship among men of science, the Society's premises offer useful club facilities.

National Foundation for Scientific Research, Brussels

The twentieth annual report of the National Foundation for Scientific Research, Brussels, for the year 1946–47, gives lists of members of the various commissions, and a note on the Inter-University Institute of Nuclear Physics. It also includes full details of the forty-five research grants made for the year 1947–48, amounting to 2,062,500 francs, and an analysis of the distribution of grants made since the establishment of the Foundation. Special grants for the period 1947–48 have been allotted to M. Biquet for sinking wells in water-bearing strata for the study of the freezing of dead ground at great depths (150,000 francs); to Prof. F. Mayence for excavation at Apamée (100,000 francs); to MM. Gratia, Florkin, Massart and Desreux for completing the existing installation of apparatus for electrophoresis by a high-quality optical apparatus of the Klett or Pearson type (100,000 francs); and to Prof. Piccard and Prof. Cosyns for submarine investigations at great depths. A list of publications during the year by those receiving grants during 1945–47, arranged under authors' names, is appended.

International Union of Crystallography

The first General Assembly and Congress of the recently formed International Union of Crystallography was held at Harvard University, Cambridge, Mass., during July 28–August 3 and was attended by some 350 crystallographers of ten nations. In recognition of his epoch-making contribution to the modern development of the subject, Prof. M. von Laue (Germany) was unanimously elected honorary president of the Union. Officers were elected as follows: *President*, Sir Lawrence Bragg (Great Britain); *Vice-Presidents*, A. Westgren (Sweden), R. W. G. Wyckoff (United States); *General Secretary*, R. C. Evans (Crystallographic Laboratory, Cavendish Laboratory, Cambridge); other members of the Executive Committee are M. J. Buerger (United States), P. P. Ewald (Great Britain), A. L. Patterson (United States), J. Wyart (France). Statutes and by-

laws of the Union were adopted, and the adhesion of Great Britain, the United States, Canada and Norway was recognized. Commissions of the Union were established as follows: *Acta Crystallographica*, International Tables, Structure Reports, Crystallographic Apparatus, Nomenclature, Crystallographic Data. Crystallographers throughout the world interested in the work of any of these Commissions are invited to make contact with them through the General Secretary. The second General Assembly and Congress will be held in Europe during the summer of 1951.

Mechanization of African Agriculture

PROBLEMS likely to be encountered in the mechanization of African agriculture are to be studied by a mission which is visiting Uganda, Tanganyika, Nyasaland and Nigeria. The leader is Dr. J. R. Raeburn, of the Agricultural Economics Research Institute, Oxford, and he is accompanied by Mr. J. W. Y. Higgs, lecturer in agricultural economics, University of Reading, and Mr. R. K. Kerkham, Uganda Agricultural Service, who is at present stationed at the Uganda Agricultural Research Station. The terms of reference are: "To make a systematic survey of the sociological, economic, agricultural and technical problems which must be studied if mechanization of agriculture in the Colonies is to develop along sound lines, including *inter alia* the forms or organization required to achieve the best results (for example, whether mechanization should be on a co-operative, group or peasant basis), the most profitable lines of future research into problems arising out of mechanization, the economics of it and the types of tractors and implements which would be likely to be most suitable to the differing African communities, and such questions as the technical training of African craftsmen, the division and displacement of labour which will result from mechanization and its impact on current farming and social systems."

Colonial Service Appointments

THE following appointments in the Colonial Service have been announced: A. Bolton, plant breeder, Kenya; E. A. Rosenquist, botanist, Malaya; J. A. F. Gerrard, geophysicist, Uganda; A. D. Campbell, veterinary officer, Nigeria; D. W. D'Silva, assistant conservator of forests, British Honduras; H. T. Hayes, fisheries officer, Gold Coast; G. H. Lunam, fisheries officer, Nigeria; D. M. Rhodes, fisheries officer, Uganda; O. E. Symes, fisheries development officer, Nigeria; T. R. Hayes (principal agricultural officer, Uganda), assistant director of agriculture, Uganda; R. B. Jagoe (botanist, Federation of Malaya), senior botanist, Federation of Malaya; H. T. Pagden (entomologist, Federation of Malaya), senior entomologist, Federation of Malaya; D. H. Welsh (agricultural officer, Nigeria), principal of schools, Agricultural Department, Nigeria; D. B. Fanshawe (assistant conservator of forests, British Guiana), senior assistant conservator of forests, British Guiana.

Effect of Lightning Discharge

PROF. E. W. MARCHANT, 20, Harthill Road, Liverpool, 18, writes: "During a severe thunderstorm in Liverpool on July 31, the centre of the roadway was struck by lightning. The lightning discharge produced a crack about six feet long in the asphalte road surface near the centre of the road and close to a manhole cover, which, I understand, was open at the time of the storm. Six or seven pieces of melted tar were scattered over the road close to the crack. Heavy rain was falling at the time and the interesting thing about the discharge was that it struck the flat surface of the road, although, only thirty feet away on each side, were trees about twenty feet high."

Announcements

DR. ANDRÉ DANJON, director of the Paris Observatory, has been elected a member of the Section of Astronomy of the Paris Academy of Sciences, in succession to the late Dr. Henri Deslandres.

DR. W. A. MACFARLANE, director of fuel efficiency in the Ministry of Fuel and Power, has been lent by the Ministry to the Department of Scientific and Industrial Research for about two years for appointment as director of the United Kingdom Scientific Mission in the British Commonwealth Scientific Offices in Washington. He will also be attaché for scientific matters in the British Embassy. In accordance with arrangements made at the time of his appointment, the present director of the Mission, Dr. F. N. Woodward, is returning to the United Kingdom towards the end of the year.

THE Public Health and Municipal Engineering Congress and Exhibition will be held at Olympia, London, during November 15–20. Further information can be obtained from the Joint Hon. Secretary, 84 Eccleston Square, London, S.W.1.

THE twenty-third annual conference of the Association of Special Libraries and Information Bureaux (ASLIB) will be held at Ashorne Hill, near Leamington Spa, Warwickshire, during September 17–20. Further information can be obtained from the Secretary, ASLIB, 52 Bloomsbury Street, London, W.C.1.

THE Council of the Royal Society of Arts is offering, under the Thomas Gray Memorial Trust, the objects of which are "the Advancement of the Science of Navigation and the Scientific and Educational interests of the British Mercantile Marine", a prize of £50 for an essay on "The Applications of Radar to Navigation". Further information can be obtained from the Secretary, Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

The South African Journal of Science of March 1948 reports the Oudtshoorn meeting in July 1947 of the South African Association for the Advancement of Science. It includes the presidential address by Prof. H. H. Paine, "The World View of the Physicist", and the addresses of the sectional presidents. Of these, Prof. C. C. Gillie reviewed "A Century of Astrophysics", Dr. C. N. C. Hamilton dealt with "Coal", Prof. A. Quintanilha with "The Problem of Cotton Production in Portuguese Africa", Dr. C. S. Grobbelaar with "Anthropometry and its Role in South Africa", the Abbé H. Breuil with "Ancient Raised Beaches and Prehistoric Civilizations in South Africa", and J. D. Rheinallt Jones with "The Development of Central and Southern Africa", including a few suggestions for research and action on some of the problems common to these territories. A number of the papers read at the meeting are also printed.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Mechanism of the Oxidation of Gaseous Formaldehyde

RECENTLY, Axford and Norrish[1] have put forward a scheme for the oxidation of gaseous formaldehyde in the temperature range 325°–375° C. Though this scheme accounts for the experimental facts, we regard the proposed initiation reactions as unsatisfactory, for they suggest that formaldehyde is oxidized directly to formic acid, whereas it is highly probable that this does not take place in a single step. Our recent experiments on the oxidation of gaseous acetaldehyde[2] have led us to propose as an initiation process the reaction of an oxygen molecule with an acetaldehyde molecule to form the acetyl radical and the perhydroxyl radical (HO_2). If an analogous initiation reaction is postulated for the oxidation of formaldehyde, we have

$$HCHO + O_2 = HCO + HO_2.$$

The formyl radical is thought to be unstable[3,4] above 100° C., and it can reasonably be assumed that at high temperatures it will split up rapidly to give carbon monoxide and hydrogen. Then our first step becomes

1. $HCHO + O_2 = H + CO + HO_2$ k_1 initiation.

The subsequent reactions we suppose to be the same as those put forward by Axford and Norrish,

2.	$H + HCHO = H_2 + CO + H$	k_2	propagation–decomposition
3.	$H + O_2 + HCHO = H_2O + CO + OH$	k_3	propagation–oxidation
4.	$OH + HCHO = H_2O + CO + H$	k_4	
5.	$H + O_2 + HCHO = H_2O + CO_2 + H$	k_5	
6.	$H + O_2 + X = HO_2 + X$	k_6	termination
7.	$H + O_2 + O_2 = HO_2 + O_2$	k_7	
8.	$H + O_2 + \text{wall} = HO_2$	k_8	

Since the chains are started by reaction (1) and terminated only by reactions (6), (7) and (8) we have, following Axford and Norrish[1]:

$$k_1(O_2)(HCHO) = k_6(H)(O_2)(X) + k_7(H)(O_2)^2 + k_8(H)(O_2)(S)/d$$

(for cylindrical vessels the ratio area/volume is $1/d$, approximately, so if (S) represents the surface activity per sq. cm., then $(S)/d$ is the surface activity per unit volume). From this we get

$$(H) = \frac{k_1(HCHO)}{k_6(X) + k_7(O_2) + k_8(S)/d}. \quad (9)$$

For the equilibrium concentration of OH radicals we have

$$k_3(H)(O_2)(HCHO) = k_4(OH)(HCHO).$$

Hence

$$(OH) = k_3 \frac{(H)(O_2)}{k_4}. \quad (10)$$

Substituting for (H) from (9) into (10) we get

$$(OH) = \frac{k_1 k_3 (O_2)(HCHO)}{k_4\{k_6(X) + k_7(O_2) + k_8(S)/d\}}. \quad (11)$$

The rate of disappearance of formaldehyde is, therefore, given by

$$-\frac{d(HCHO)}{dt} = k_1(HCHO)(O_2) + k_2(H)(HCHO) + (k_3 + k_5)(H)(O_2)(HCHO) + k_4(OH)(HCHO). \quad (12)$$

Substituting for (H) and (OH) from equations (9) and (11) we get

$$-\frac{d(HCHO)}{dt} = k_1(HCHO)(O_2) + \frac{k_1 k_2 (HCHO)^2}{k_6(X) + k_7(O_2) + k_8(S)/d} + \frac{k_1(O_2)(HCHO)^2(2k_3 + k_5)}{k_6(X) + k_7(O_2) + k_8(S)/d}. \quad (13)$$

This is the same as equation (IV) given by Axford and Norrish on page 534 of their paper[1]; thus this modified scheme, also, accounts for the experimental results. It has, however, the advantage of a more clear-cut initiation step and also shows why one gets performic acid at low temperatures, for here the formyl radical will be stable and the following reactions can take place.

$$HCHO + O_2 = HCO + HO_2. \quad (14)$$

$$HCO + O_2 = HCOOO. \quad (15)$$

$$HCOOO + HCHO = HCOOOH + HCO. \quad (16)$$

This is analogous to the scheme which we are putting forward to explain the occurrence of peracetic acid in the low-temperature oxidation of acetaldehyde.

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April 13.

[1] Axford, D. W. E., and Norrish, R. G. W., *Nature*, **160**, 537 (1947): *Proc. Roy. Soc.*, A, **192**, 518 (1947).
[2] McDowell, C. A., and Thomas, J. H. (unpublished experiments).
[3] Akeroyd, E. I., and Norrish, R. G. W., *J. Chem. Soc.*, 890 (1936).
[4] Leermakers, J. A., *J. Amer. Chem. Soc.*, **56**, 1537 (1934).

ANY initiation process which will provide one of the chain centres responsible for the propagation reaction, and the rate of which depends upon the product of the pressures of formaldehyde and oxygen, may be substituted for that which we propose without change in the structure of the kinetics. It is thus not surprising that there is no formal change in the derivation of the relationship which Messrs. McDowell and Thomas reproduce from our paper. Initiation reactions, however, can be distinguished by studying the overall activation energy of the chain reactions which they initiate and to which they make the principal contribution, and in choosing the most likely initiation reaction, reference must be made to the thermochemistry of the processes postulated. Now the overall temperature coefficient of the oxidation of formaldehyde at 350° C. indicates an energy of activation of about 20 k.cal., and nearly all of this is associated with the initiating process, for which the velocity coefficient is k_1. Thus the initiation process at the temperature studied cannot be more endothermic than *c.* 20 k.cal., and is probably less so. From the data of Bray[1] we may derive

$$H + O_2 = HO_2 + 52 \text{ k.cal.};$$

and combining this with

$$H + HCO = H_2CO + 102 \text{ k.cal.},$$

we may calculate that the reaction

$$H_2CO + O_2 = HCO + O_2$$

is endothermic to the extent of 50 k.cal. Since this figure must give a lower limit for the energy of activation, it would appear that the reaction cannot function as an initiating process for the formaldehyde oxidation in the range of temperature where the overall energy of activation is 20 k.cal.

On the other hand, from the heats of combustion of formaldehyde and formic acid, and the heat of dissociation of molecular oxygen, we may calculate a heat absorption of about 8 k.cal. for the initiation process:

$$HCHO + O_2 = (HCOOOH) = HCOOH + O$$

postulated by us. This endothermicity is less than the energy of activation at 350° C. and is thus in accord with the experimental results.

Our initiation reaction involves the formation of performic acid as a transition compound, followed by its decomposition to give an oxygen atom; this would explain the occurrence of performic acid at the lower temperatures at which it is stable, and a similar scheme would give peracetic acid in the case of acetaldehyde. We have never supposed that the reaction takes place in a single step as suggested by Messrs. McDowell and Thomas. On the other hand, there is no case for dogmatizing, and we hope to get further evidence from a more detailed study of the temperature coefficient of the reaction. There are reasons for believing that more than one initiation reaction can operate, each in a different temperature range, without essentially changing the kinetic scheme we have derived, and at higher temperatures the alternative which has been suggested is not excluded.

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[1] Bray, *J. Amer. Chem. Soc.*, **60**, 82 (1938). See also Rollefson, "Photochemistry", 276 (Prentice-Hall, 1939).

Further Experimental Evidence for the Theory of Quasi-Properties

Scott Blair, Veinoglou and Caffyn[1] have explained the rheological behaviour of certain complex materials in terms of 'quasi-properties'; that is, complex entities in which a number of magnitudes taken together describes the process which the material undergoes as a result of a specified test, the ordinary 'properties', such as viscosity and elasticity, being changed by the testing process itself.

The simplest illustration of this is the Nutting[2] equation

$$\psi = S^{\beta}\sigma^{-1}t^{k}, \qquad (1)$$

where S is stress, σ is strain, t is time, and where ψ is a constant which can only describe the relative behaviour of materials when quoted in conjunction with k and β, which are numbers specifying its dimensions. In the limit, when β and k have constant values for large groups of materials, ψ approximates in character to a physical property of the ordinary kind.

Many materials subjected to constant compressive or tensile stresses or relaxing at constant strain after rapid straining accurately obey equation (1); but a few, especially when relaxation follows a slow straining, show considerable discrepancies.

In our earlier paper* we proposed 'intermediate' fractional differential equations of the type:

$$\text{Prototypes} \begin{cases} \eta = S \div \dfrac{d\sigma}{dt} \\ n = S \div \sigma \\ \eta = t \div \dfrac{d\sigma}{dS} \\ \pi = t \div \dfrac{\sigma}{S} \end{cases} \begin{cases} \chi_1 = S^{\beta} \div \dfrac{\partial^{\mu}\sigma}{\partial t^{\mu}} \quad (2a) \\ \chi_2 = t^{k} \div \dfrac{\partial^{\omega}\sigma}{\partial S^{\omega}} \quad (2b) \end{cases} \frac{1}{X} = \frac{d^{\mu+\omega}\sigma}{dt^{\mu}.dS^{\omega}} \qquad (2)$$

where F indicates fractional differentiation. Equation (2a) may be integrated to give:

$$\sigma = At^{k} + Bt^{k-1} + Ct^{k-2}, \qquad (3a)$$

and it was shown that the great majority of those of our data which did not obey equation (1) could be accounted for by introducing the second term of equation (3a) and, in a few cases, the third term.

We have now examined the rest of the anomalous data and have fitted both the integrated form of equation (2b):

$$\sigma = A'S^{\beta} + B'S^{\beta-1} \qquad (3b)$$

as well as the general integrated form of equation (2):

$$\sigma = (At^{k} + Bt^{k-1} \ldots)(A'S^{\beta} + B'S^{\beta-1} \ldots). \qquad (3)$$

(The product is preferred to the sum of equations (3a) and (3b), though both are valid integrations of equation (2).)

In all the data examined, we have found that with no more than two terms in each case, either equation (3a), (3b) or (3) fits our data within the limits of experimental error, which are satisfactorily low.

Since the ratios B/A and B'/A' have the dimensions of time and stress respectively and represent characteristics of the materials, it should be possible to write the three equations in dimensionless form by expressing all times and stresses in terms of these characteristics. Deviations from the simple Nutting equation are rarely large enough, however, for such a procedure to give reasonable accuracy.

In our earlier paper we explained that the fractional differentials with respect to time arise as a result of the use of the Newtonian definition of equality of time units, the acceptance of which *defines* the velocity of light, or of bodies free from the influence of other matter as constant.

Just as the Newtonian time-scale depends on the constancy of the magnitude of such velocities, so it seems that Newtonian definitions of equality of forces, unless directly involving Newtonian time, must depend on the concept of a straight line or of unchanging direction, that is, the *course* of a light ray or of a body uninfluenced by other matter.

For example, two forces, X and Y, might be defined as equal when, acting in the same direction on a body, a third force, Z, can be found which would balance either of them so that the body would not change its motion as a result of the simultaneous actions of either X–Z or Y–Z. If the body is of finite size, X (or Y) and Z must be acting in a straight line: if the body becomes a point, there can be no change in direction at this point.

The implications of this in relation to the stress fractional differentials (equations 2b and 3b) are discussed in a paper in process of publication (*Phil. Mag.*), in which the full experimental results are also given.

Our indebtedness to several colleagues who have helped us is expressed in our paper itself. Here we wish to acknowledge our gratitude to the British

* The equations are here re-written in a slightly more convenient form.

Electrical Research Association for permission to publish this work, to the Agricultural Research Council for a grant to one of us (J. E. C.), and to Dr. L. J. Comrie for most of the calculations.

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[1] Scott Blair, G. W., Veinoglou, B. C., and Caffyn, J. E., *Proc. Roy. Soc.*, A, **189**, 69 (1947).
[2] Nutting, P. G., *J. Franklin Inst.*, **191**, 679 (1921).

Ionic Reactions in Liquid Dinitrogen Tetroxide

The fact that liquids other than water may serve as media for inorganic reactions is widely recognized; reactions in the well-known liquid ammonia and liquid sulphur dioxide systems are explained by postulating the ionization:

$$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$
$$2SO_2 \rightleftharpoons SO^{2+} + SO_2^{2-},$$

although neither liquid has an appreciable electrical conductivity. Frankland and Farmer[1] in 1901 first considered the possibility that liquid dinitrogen tetroxide might serve as an ionizing medium, but were unable to find any inorganic salt which was soluble in the liquid. In view of the high solubility of many organic compounds, they concluded that the liquid was of a non-ionizing character and resembled in behaviour such organic solvents as benzene.

We have now obtained evidence that ionic reactions can be conducted in liquid dinitrogen tetroxide medium. Where electron-transfer can readily occur, all reactions so far investigated in this medium can be interpreted on the basis of the ionization:

$$N_2O_4 \rightleftharpoons NO^+ + NO_3^-. \qquad (1)$$

The existence of the nitrosyl radical is already established in other media[2,3], and we have found no evidence for dissociation of the N_2O_4 into NO_2^+ and NO_3^- under these conditions. Thus the alkali metals, including lithium, react rapidly but quietly with liquid dinitrogen tetroxide to yield the nitrate and nitric oxide:

$$Na + N_2O_4 \rightarrow NaNO_3 + NO. \qquad (2)$$

The reaction is not affected, except in velocity, by dilution of the dinitrogen tetroxide with an inert solvent such as benzene. The insoluble nitrate produced is free from nitrite. At temperatures approaching the boiling point of dinitrogen tetroxide (21·3°) the nitric oxide is evolved (although at low temperatures, or under pressure, some nitric oxide remains associated in the liquid phase as blue dinitrogen trioxide), and the reaction can be considered as a simple electron transfer from the sodium atom to the NO^+ ion, giving the resonance-stabilized nitric oxide molecule. Attempts to explain this reaction on the basis of dissociation of the medium into NO_2^+ and NO_3^- would involve the intermediate formation of the alkali metal nitrite, which we have found to be stable in contact with liquid dinitrogen tetroxide. Although some metallic oxides when allowed to react with dinitrogen tetroxide yield nitrite as well as nitrate, this is probably at least a two-stage reaction which may be explained thus: $MO + (2NO^+ + 2NO_3^-) \rightarrow M(NO_3)_2 + 2NO^+ + O^{2-}$, followed by $MO + 2NO^+ + O^{2-} \rightarrow M(NO_3)_2$, and the formation of nitrite here does not necessarily imply the presence of NO_2^- in the medium.

Ammonium chloride (in liquid ammonia) and thionyl chloride (in liquid sulphur dioxide) have many properties commonly associated with aqueous hydrochloric acid solutions. The corresponding compound in the liquid dinitrogen tetroxide system, nitrosyl chloride, is soluble in this medium and such solutions attack many of the metals which are resistant to the tetroxide alone, the degree of attack depending on the concentration of the nitrosyl chloride; nitric oxide is evolved, the insoluble product being either the metal chloride or the chloride associated with nitrosyl chloride as a complex of the type $(NO)_x[MCl_y]$.

The ionic dissociation of dinitrogen tetroxide (equation 1) is fully reversible in the liquid phase. Thus the reaction:

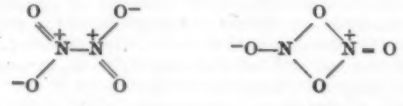
$$NOCl(\text{in } N_2O_4) + AgNO_3(s) \rightarrow AgCl(s) + N_2O_4(l)$$

(comparable with the reaction between an aqueous solution of hydrogen chloride and an insoluble hydroxide) is complete in the direction indicated. However, if dry diethylammonium chloride is added to liquid dinitrogen tetroxide at 0° the reaction:

$$[Et_2NH_2]^+Cl^- + N_2O_4 \rightarrow NOCl + [Et_2NH_2]^+NO_3^- \qquad (3)$$

proceeds readily. The medium is immediately coloured red by the nitrosyl chloride produced, and diethylammonium nitrate may be crystallized from the solution; the process resembles that of hydrolysis. At higher temperatures the products of reaction (3) undergo further mutual interaction.

Full details of the work will be published elsewhere, but it is of interest here to compare the behaviour of dinitrogen tetroxide outlined above with its reactions where bonds of a covalent character are involved. Levy and Scaife[4] have shown that it adds to olefinic double bonds to give exclusively dinitro-compounds or nitro-nitrites. Again, both ammonia and diethylamine react explosively with it, yet ammonium and diethylammonium chlorides and nitrates are unattacked, so that the conversion of the base into the ionic form shields it from decomposition by dinitrogen tetroxide. We are led to the conclusion that the dinitrogen tetroxide molecule may undergo dissociation in two ways during reaction, giving either $(NO^+ + NO_3^-)$ or $(NO_2^+ + NO_2^-)$, and that the particular course followed depends upon whether the reacting groups are charged ions or covalent, uncharged molecules. It is not our desire here to support any particular structure for the dinitrogen tetroxide molecule; but our work on ionic reactions has shown that the molecule should be capable of dissociation into NO^+ and NO_3^- units as a result of simple electron transfer processes. Ingold[5] considers that the results of Levy and Scaife[4] provide additional and conclusive proof of structure (I).



(I) (II)

Ionic dissociation of this molecule (equation 1) would involve the breaking of the N–O bond and transfer of the oxygen atom, whereas ionization of molecule (II) postulated by Longuet-Higgins[6] would involve

no atom transfer, while at the same time satisfying physical evidence regarding symmetry[7].

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May 1.

[1] *J. Chem. Soc.*, 1356 (1901).
[2] Angus and Leckie, *Trans. Farad. Soc.*, **31**, 958 (1935).
[3] Klinkenberg, *Chem. Weekblad*, **35**, 197 (1938).
[4] *J. Chem. Soc.*, 1093 (1946).
[5] *Nature*, **159**, 743 (1947).
[6] *Nature*, **153**, 408 (1944).
[7] Sutherland, *Proc. Roy. Soc.*, A, **141**, 342 (1933).

A General Solution for the Force Constants of Polyatomic Molecules

It is well known that the fundamental vibration frequencies of polyatomic molecules can be predicted with an error of only 1 or 2 per cent by solving the secular equation with force constants obtained from related molecules[1]. The reverse process of solving for the constants in terms of the frequencies is, in general, impossible unless some special assumptions are made concerning the force field[2]. The following general solution is therefore of some interest.

The nth order secular equation can be written in matrix form as follows:

$$|dA-\lambda I| = 0. \tag{1}$$

The elements of d are the force constants d_{ij} in the general potential function:

$$2V = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}\Delta_i\Delta_j. \tag{2}$$

The Δ_i are valence-type co-ordinates, expressed in terms of N further co-ordinates z_j:

$$\Delta_i = \sum_{j=1}^{N} a_{ij}z_j, \tag{3}$$

all possessing any required symmetry properties, and the elements of A (related to the inverse kinetic energy matrix G used by Wilson[3]), are defined as follows:

$$A_{ij} = A_{ji} = \sum_{k=1}^{N} a_{ik}a_{jk}\frac{M}{m_k}, \tag{4}$$

m_k being the mass for the co-ordinate z_k and M some arbitrary mass, introduced in order that the A_{ij} shall be pure numbers. I is the unit matrix, and the quantity λ is defined as follows:

$$\lambda = 4\pi^2\nu^2c^2M, \tag{5}$$

ν being the frequency of vibration in cm.$^{-1}$ and c the velocity of light in cm. sec.$^{-1}$. The $(N-n)$ null vibrations factorize out, giving (1). If the subscripts are ordered so that Δ_i is the approximate normal co-ordinate for ν_i, corresponding to the vibrational assignment, and if $\nu_1 > \nu_2 \ldots > \nu_n$, then the proposed general solution for the constants is obtained by equating to zero all elements below the diagonal of the determinant (1), thus reducing it to the product of n linear factors, and substituting λ_1 to λ_n in order in the n diagonal elements; that is:

$$\left.\begin{aligned}&\sum_{i=1}^{n} A_{ki}d_{ki}-\lambda_k = 0, \ (k = 1, 2 \ldots n).\\ &\sum_{i=1}^{n} A_{qi}d_{pi} = 0, \ (p > q).\end{aligned}\right\} \tag{6}$$

The corresponding (unnormalized) normal co-ordinates are given by:

$$z_i^{p_k} = \sum_{j=1}^{k} a_{ji}\frac{M}{m_i}\,{}^{k}|A|_{kj} \tag{7}$$

$$\Delta_p^{p_k} = \sum_{j=1}^{k} A_{pj}\,{}^{k}|A|_{kj}, \ (= 0 \text{ for } p < k). \tag{8}$$

where ${}^{k}|A|_{kj}$ are first minors of the kth order determinant formed from the first k rows and columns of the matrix A. The normal co-ordinate for ν_i involves only the co-ordinates Δ_i to Δ_n; the method, in effect, factorizes out the frequencies in descending order, the molecule increasing in rigidity as factorization proceeds. If only the constants for the m lowest frequencies are required, only elements in the last m rows of (1) need be considered, without introducing any fresh approximation.

The above solution is found to give surprisingly good results with actual examples, and is easy to apply. For molecules in which all the fundamentals fall into the category of 'group vibrations', factorization of the secular equation will clearly give a close approximation; where $(\nu_i - \nu_{i+1})$ is small and Δ_i and Δ_{i+1} overlap, the approximation will not be so close, since the normal co-ordinate for ν_{i+1} would then certainly involve Δ_i; but only the constants d_{ii}, $d_{i(i+1)}$ and $d_{(i+1)\,(i+1)}$ will be much affected. The constants obtained in (6) are always real, and the normal co-ordinates defined in (7) and (8) correspond to the vibrations having idealized geometrical forms; thus, in valence vibrations the atomic displacement vectors lie directly along the appropriate valence bonds. Interactions which would normally be discarded are here generally found to be negligibly small; their retention gives the unambiguous solution.

The method can obviously be adapted to predict vibration frequencies, by substituting constants only in the diagonal elements of (1); the inconsistency in the force field can then be estimated by evaluating terms below the diagonal.

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May 6.

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Study of the Action of Ultra-violet Light on Urease by Means of the Ultracentrifuge

The action of ultra-violet light on serum albumin has been studied with the ultracentrifuge by Svedberg and Brohult[1] and by Sanigar, Krejci, and Kraemer[2]. Irradiation of serum albumin at room temperature and at 0° C. causes the formation of low-molecular substances and a general inhomogenization of the protein.

It seemed worth while to perform a similar experiment with a protein having enzymatic activity in order to see if inhomogenization accompanies loss of activity, or is a process resulting from the absorption of quanta beyond those required on the average for inactivation. For irradiation, monochromatic light of 2537 A. was used, at which a quantum yield of inactivation of 0·000926 has been found[3]. Inactiva-

tion involves a 'one-hit' process, that is, only one quantum is required for inactivation, although many (1,100) quanta may be absorbed on the average without producing inactivation.

A solution (0·5 per cent) of crystallized urease, pH 7 in 0·02 *M* phosphate buffer, was sedimented at 60,000 times gravity. It gave a sedimentation constant, S_{20}, of 18·2 Svedberg units, with a heavier component, S_{20} equal to 27·5, present to the extent of about 20 per cent of the total protein. This compares within the experimental error with earlier results of Sumner *et al.*[4], who found S_{20} equal to 18·6 for the main component in their best preparation. After a loss in activity of 45 per cent by irradiation, a main component with S_{20} equalling 15·0 was present to the extent of 60 per cent of the main component of the control sample. Comparison showed an increase in the amount of material both lighter and heavier than the main component. In a second experiment the activity of one aliquot was reduced to 66 per cent by radiation, and of another aliquot to 63 per cent by heating in a water bath at 80°. After irradiation, a fairly sharp main component remained. Following heat denaturation, however, no clearly defined component was visible, the material having become extremely polydisperse and inhomogeneous.

These results show that the decrease in activity of the irradiated solutions was about equal to the decrease in concentration of the main component, and the average molecular weight of this component was somewhat decreased. This, together with the appearance of more heavy material, suggests that irradiation brings about a primary process of inactivation and depolymerization followed by aggregation of the depolymerized material. Adjustment of irradiated solutions to the isoelectric point is known to augment this second step by inducing precipitation[2]. That ultra-violet light is more specific in its action than is heat is also indicated. The latter agent produces a more general distribution of particle sizes resulting, doubtless, from a spectrum of energy which breaks bonds at random. Monochromatic light, however, which is selectively absorbed at aromatic residues[3], would tend to produce more well-defined fragments by breakage of bonds next to chromophores.

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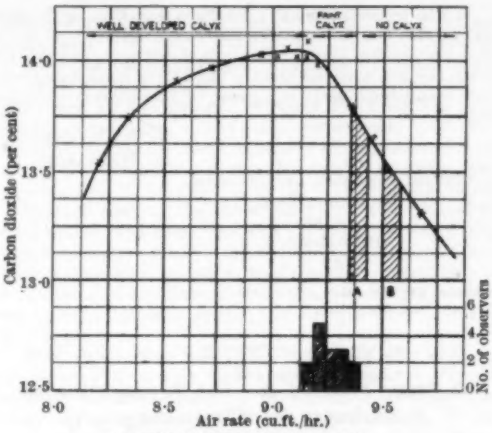
Use of the Calyx Burner to Determine Combustion Conditions

H. Rostron Hindley[1] has recently directed attention to the limitations of the calyx flame as an indicator of maximum carbon dioxide concentration in products of combustion. His letter seemed to us inconclusive, as the scale of air flow in the accompanying diagram was arbitrary and hence gave no indication of the magnitude of the possible error in terms of air/gas ratio. There was also no indication of the



Gas rate, 2·49 cu.ft./hr. throughout.
A, total air requirement calculated from analysis
B, " " " using Wood's formula (lines indicate limits of probable error)

relation between the peak concentration of carbon dioxide and the theoretical mixture. It cannot be assumed that these two points would coincide under the combustion conditions prevailing in the calyx burner. As we had not previously considered the calyx flame as an indicator of maximum concentration of carbon dioxide, it was thought to be worth while making further tests with this application in mind.

Using a calyx burner of the type described by Brinsley and Stephens, determinations of the total air requirement of Birmingham towns gas were made by three observers having considerable experience of calyx observation, one of whom was known from previous special tests to have sensitive colour vision. Comparison was made with twelve other observers used to scientific observations but having no special training in, or experience of, calyx observation. One of these observers was also known to have specially sensitive colour vision. At the same time a series of carbon dioxide determinations were made, and the total air requirements of the gas were calculated both directly from the gas analysis data and also using J. W. Wood's formula[2]. As an additional confirmation of the value of the maximum carbon dioxide concentration an analysis was made of the products of combustion from a Boys calorimeter and the carbon dioxide calculated on an oxygen-free basis. This confirmed the peak concentration shown on the full line in the accompanying diagram.

The point of disappearance of the calyx as determined by the two colour-sensitive observers fell consistently on the left-hand limit of the region marked 'no calyx'. The end points in the case of all the other observers except one fell between the right-hand end of the range marked 'well developed calyx' and the 'no calyx' limit. One observer had difficulty in seeing the calyx under any conditions. The frequency distribution of observations adjusted to a constant number of observations per observer is also shown on the diagram. Although the number of observers is insufficient to obtain a statistically valid distribution, this information is included for the sake of completeness. The extreme range of error in the determination of air/gas ratio was about ± 1·5 per cent, which is sufficiently accurate for most purposes connected with gas appliance design and with observations of gas quality.

It will be seen from the diagram that the end points of the two colour-sensitive observers agreed well with the values for the total air requirement calculated from the gas analysis data. The latter were definitely not coincident with the peak of the carbon dioxide curve.

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A New Method for the Preparation of Adsorbents for Chromatography

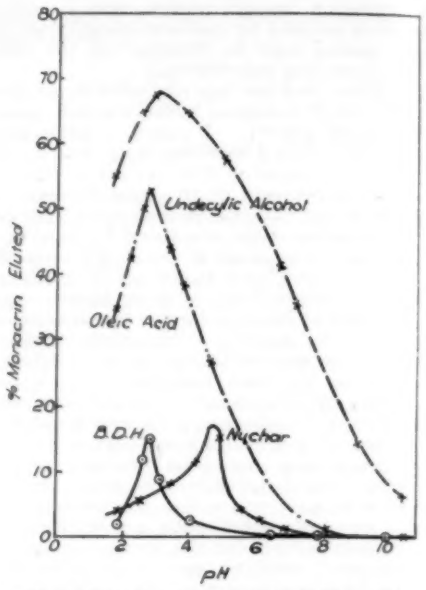
The technique of chromatography, as used at present, is limited to a few adsorbents and usually to non-aqueous systems, due to the difficulty of elution of the adsorbate. However, aqueous systems could be used if adsorbents were available which permitted adsorption and desorption to be controlled by *p*H adjustment. This procedure is possible in some cases with synthetic ion exchange resins which have been used to a limited extent for the separation of mixtures of inorganic ions, organic bases such as thiamine, and some amino-acids. However, organic bases cannot always be recovered quantitatively even by elution with strong acids. 'Sodium cotton succinate' has been used for the quantitative adsorption and recovery of histamine, which could not be eluted quantitatively from ion exchange resins[1].

Activated charcoal has not generally been used for chromatographic separation of water-soluble substances because of its high adsorptive power and the subsequent difficulty of elution. It has been used for three-stage countercurrent adsorption of certain antibiotics such as penicillin, where an organic solvent is used for elution, followed by an additional extraction into buffered solution.

By adsorption of a surface-active or water-insoluble acid, for example, fatty acids or lecithin, as a 'primary' adsorbate, on adsorbents such as alumina, activated charcoal, or even carbon black, I have prepared a simple and versatile adsorbent similar in behaviour to an ion exchange resin. The adsorbent acquires the properties of the 'primary' adsorbate, and forms, under alkaline conditions, salts with cations or bases which may be considered as a 'secondary' adsorbate. The 'secondary' adsorbate can be eluted by acid solution. This eliminates the use of organic solvents and permits the immediate re-use of the prepared adsorbent.

Cationic surface-active agents, or insoluble bases, may be used in place of the fatty acids as a 'primary' adsorbate to prepare adsorbents for acids or anions. Similarly, the 'primary' adsorbate may be any substance that can form a complex with the materials to be separated or fractionated; for example, the lignin protein reaction might be utilized for the fractionation of some protein mixtures.

Typical curves for the adsorption of 'Monacrin' (5-amino acridine) directly on 'Nuchar' and B.D.H. decolorizing charcoal (reproduced herewith) are in agreement with the findings of Hauge[2], Olin[3] and Sastri[4], who showed that the adsorption of electro-



0·05 gm. adsorbent; 10 ml. 4 × 10⁻³ *m*/*L* 'Monacrin'

positive substances on activated charcoals is a minimum in the region of a characteristic *p*H termed the isoelectric point.

A similar curve is also shown for the adsorption of 'Monacrin' on B.D.H. charcoal pretreated with 20 per cent of its weight of oleic acid. Two distinct adsorption processes occurred. The curves indicate that above a *p*H value of approximately 6, the 'Monacrin' reacted with oleic acid to precipitate an insoluble salt on the adsorbent. In this *p*H range the salt formation was the principal adsorption mechanism, and strong adsorption was observed for both strong and weak adsorbents, such as B.D.H. charcoal and acetylene black. Below this *p*H-range, free base was liberated from the salt and was apparently adsorbed on the oleic acid layer, the degree of adsorption depending on the adsorptive power of the carbon. Thus B.D.H. charcoal showed a minimum adsorption amounting to 50 per cent of the 'Monacrin' at *p*H 3·0, whereas acetylene black similarly treated with oleic acid showed practically complete elution. Increasing the amount of adsorbed oleic acid in the pretreatment reduced the 'Monacrin' adsorption.

By selecting a carbon with a suitable isoelectric point, and an acid or base of the required strength, a great variety of exchange adsorbents can be prepared. For single-stage adsorptions, quantitative adsorption and elution of the adsorbate are desirable, and may be achieved by using a weak adsorbent such as acetylene black coated with oleic acid. Chromatographic separations require a stronger adsorbent to permit development.

The adsorption is also shown in the accompanying graph, under the same conditions, of 'Monacrin' on B.D.H. charcoal pretreated with 40 per cent of its weight of undecylic alcohol as 'primary' adsorbate. In this case salt formation cannot occur, and the 'Monacrin' is bound by adsorptive forces only, which appear to be electrostatic in nature[5]. Thus any factor which varies the dielectric constant of the

'primary' adsorbate film, and hence the surface charge, might be expected to alter the degree of adsorption. In this manner, a great variety of adsorbents may be prepared.

This work will be discussed in detail in a paper to be published elsewhere.

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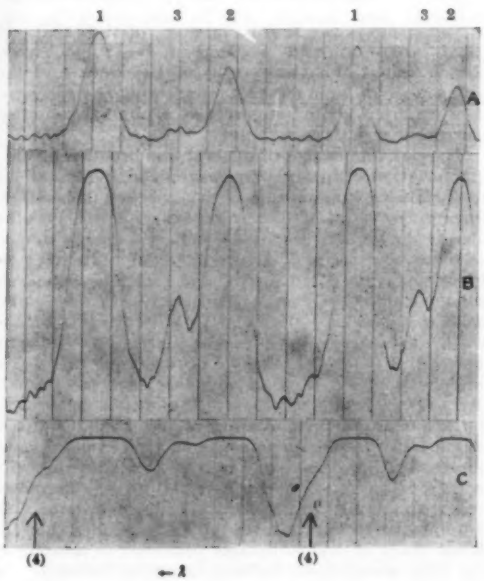
Fine Structure of the Hydrogen α-Line

Though the doublet structure of the Balmer lines has been known for sixty years, attempts at a more complete resolution of the fine structure have met with difficulties owing to the large Doppler width of the individual lines. In the α-line, a third component arising from the transitions $2S_{1/2}$–$3P_{1/2}$ and $2P_{1/2}$–$3S_{1/2}$ was resolved by Williams[1] in 1938, using a deuterium discharge tube in liquid air; but the resolution was not complete enough to allow an accurate measurement of the positions of the components. From these results, Pasternack[2] deduced a displacement of about 0·03 cm.$^{-1}$ of the $2S_{1/2}$ level from its position given by Dirac's theory. This value was no more than a rough estimate, and only through the microwave experiments of Lamb and Retherford[3] was the reality of the shift established.

By using a deuterium discharge tube immersed in liquid hydrogen and run at very low current densities ranging from 2 to 6 milliamp. per sq. cm., we have been able to resolve the third component much more completely, and under conditions where the relative intensities are in qualitative agreement with the theoretical prediction for undisturbed atoms. Fabry-Pérot étalons with spacings of 5 mm. and 7·5 mm. were used.



The photometer tracing *A* shows the main components (1) and (2), the latter appreciably weaker as predicted by the theory. Tracing *B*, of a plate with longer exposure, shows the component (3) well resolved from (2). As the result of measurement of thirty-six fringes in eleven different exposures, the spacing (3)–(1) was found to be 0·183±0·005 cm.$^{-1}$.

Though each of the three components is a blend of two unresolved lines, in both (1) and (3) one of the two constituent lines is so weak that its presence has only a small influence, a rough estimate of which is sufficient. With these corrections, our results lead to an upward displacement of the $2S_{1/2}$ level of 0·043± 0·006 cm.$^{-1}$.

This value does not agree well with the shift of 0·033 cm.$^{-1}$ found by Lamb and Retherford. These authors do not apparently claim great accuracy for their measurements; but an error of more than 10 per cent would have to be assumed to make them compatible with our results. The values of the radiation shift of the $2S_{1/2}$ level calculated by Bethe[4] and Dyson[5] are 0·033 and 0·034 cm.$^{-1}$, which agree with Lamb and Retherford's measurements, but not so well with ours.

With very long exposures, we have also been able to resolve and to measure a fourth component due to the transition $2P_{3/2}$–$3S_{1/2}$. On account of its small intensity, it had not hitherto been resolved from the fifty times stronger component (1). It can be seen in tracing *C*, in which the other lines appear broadened by over-exposure. The separation (1)–(4) was found to be 0·138 ± 0·006 cm.$^{-1}$.

The measurement of this new component allows the position of the term $3S_{1/2}$ to be determined. The value 0·138 of the separation (1)–(4) would give the position of the $3S_{1/2}$ term in almost complete agreement with Dirac's theory (only 0·003 cm.$^{-1}$ higher), whereas Bethe's theory predicts an upward shift of 0·011 cm.$^{-1}$. On account of the incomplete resolution, however, we do not claim that our value for this term is completely certain.

Further work is being done in an effort to achieve better resolution.

We are greatly indebted to Prof. F. Simon and his co-workers for the supply of liquid hydrogen.

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Photodisintegration of Deuterium and Beryllium by Thorium C″ γ-Rays

The ratio has been measured between the numbers of neutrons emitted from sources made by placing 300 mC. of radium–thorium in the centre of spheres of heavy water and beryllium respectively. These sources emit neutrons according to the well-known reactions:

$$H_1^2(\gamma,n)H_1^1 - 2{\cdot}18\ \text{MeV}. \quad (1)$$

and

$$Be_4^9(\gamma,n)Be_4^8 - 1{\cdot}63\ \text{MeV}. \quad (2)$$

$$[Be_4^8 \rightarrow 2He_2^4 + Q].$$

Since thorium C″ emits a γ-ray of 2·62 MeV. energy, this leads to neutron energies of 0·22 MeV. and 0·80 MeV. respectively.

The heavy water used was of 99·6 per cent purity and was contained in a lead glass sphere 5 cm. in diameter with a cylindrical space 9 mm. long and 7·5 mm. diameter at the centre to contain the radium–thorium capsule. The beryllium was a machined sphere of pure beryllium metal 11 cm. in diameter, with a central cylindrical space 7·5 mm. long and 6 mm. in diameter. The relative numbers of neutrons emitted from these sources have been measured by slowing them down in a large tank of water and integrating the slow neutron density set up in this tank by using manganese foil detectors, the β-activity of which is afterwards measured by means of a Geiger counter with a thin aluminium wall. This ratio is

$$N_{Be}/N_{D} = 1{\cdot}26 \pm 0{\cdot}03.$$

From this ratio, and the data above, the ratio between the photo-disintegration cross-sections for beryllium and deuterium for a γ-ray energy of 2·62 MeV. energy can be calculated, a correction being applied for absorption of γ-rays in the deuterium and beryllium, making use of the absorption coefficients given in the "Handbook of Physics and Chemistry". The ratio then becomes

$$\frac{\sigma(\gamma n)\mathrm{Be}}{\sigma(\gamma n)\mathrm{D}} = 0{\cdot}35 \pm 0{\cdot}01,$$

a value in good agreement with the recently published work of Russell, Sachs, Wattenberg and Fields[1], who found values for $\frac{\sigma(\gamma n)\mathrm{Be}}{\sigma(\gamma n)\mathrm{D}}$ of 0·30 at 2·50 MeV. γ energy, and 0·43 at 2·76 MeV. γ energy.

A second determination was made using a 'long counter'[2] instead of a water tank to compare the neutron output of the two sources. These measurements give a value

$$\frac{\sigma(\gamma n)\mathrm{Be}}{\sigma(\gamma n)\mathrm{D}} = 0{\cdot}36 \pm 0{\cdot}03,$$

in good agreement with the first method.

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Cold Working of Aluminium at Low Temperatures

At the suggestion of Prof. J. Reekie of the University of Toronto, I have carried out a few experiments on the cold working of aluminium at room and liquid air temperatures. These show that although the metal is spontaneously self-recovering during cold working at room temperatures, it shows lattice distortion effects if the plastic deformation is carried out at the temperature of liquid air and the specimen is maintained at that temperature. The aluminium used was 'H.S.' brand, supplied by Messrs. Johnson Matthey and Sons, Ltd. The X-ray back-reflexion method was chosen for investigation of lattice distortion.

An aluminium rod with quite small crystals was first cold-worked by striking with a centre punch at room temperature. X-ray back reflexion pictures taken before and after cold working showed that the radial breadth of the rings in the X-ray pattern did not increase. The aluminium was then brought to the temperature of liquid air, when a third photograph was taken. This showed no line broadening. With the specimen at the low temperature the aluminium was again cold-worked. The rings were now considerably broadened. On allowing the specimen to warm up to room temperature, it was found that the line broadening disappeared and large spots on the rings indicated the process of recrystallization.

Fig. *a* shows the line broadening of the [420] and [331] rings on cold working at −180° C., while Fig. *b* shows the sharpening of the lines and the appearance of large crystals on allowing the specimen to warm up to room temperature. Cobalt *K* radiation was used in both cases.

The possible causes of general line broadening are: (1) variation of interplanar spacings in the metal due to variations in composition; (2) thermal fluctuations during the time of exposure; (3) small crystallite size; (4) variation of interplanar spacings due to mechanical strain. Causes (1) and (2) may be ignored because of the purity of the aluminium and the absence of line broadening with an unworked specimen photographed at −180° C. It is impossible on the evidence available to differentiate with any certainty between (3) and (4). The line broadening due to the fine-grain effect is given by the Scherrer formula $\Delta B = 0{\cdot}9\lambda/t\cos\theta$, where λ is the wave-length used, t the linear particle size and θ the Bragg reflexion angle. In the present experiment this would give an increase of just less than 1 mm. in the [420] ring with cobalt *K* radiation if the crystallite size decreased from about 10^{-4} cm., when the rings become continuous, to 10^{-5} cm. Now Wood[1] concludes that the lower limit of crystallite size produced in aluminium by very severe cold working is about 10^{-4} cm. On

such a view the present line broadening of more than a millimetre would appear to be mostly due to mechanical strain.

There was no evidence in the present short series of experiments of the impossibility of producing complete rings after cold working, which was also noted in Wood's paper. Further work on this latter point will have to be done before a definite conclusion can be given.

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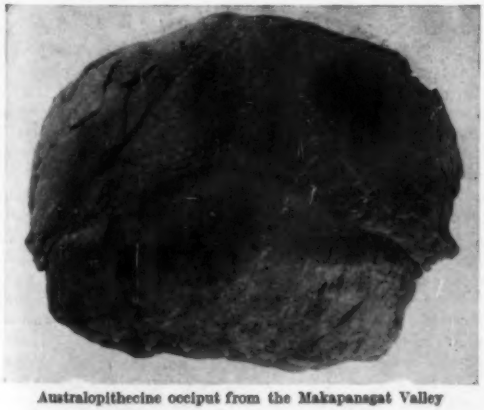
[1] Wood, W. A., *Proc. Roy. Soc.*, A, 172. 231 (1939).

A (?) Promethean *Australopithecus* from Makapansgat Valley

During 1947 the Bernard Price Foundation for Palæontological Research in the University of the Witwatersrand maintained an archæological party in the Makapansgat Valley, twelve miles north-east of Potgietersrust. Their principal objective was to excavate the Cave of Hearths, a site of human habitation containing palæoliths of Chell-Acheul facies embedded in limestone breccia.

About a mile lower down the same valley is the Limeworks site where no implements have been found and from the dumps of which students and members of the staff of the Anatomy Department have been recovering primate and other mammalian fossils for several years past. The presence of *Parapapio broomi*, Jones, in the lowest stratum of the Limeworks cavern breccia shows that this earliest stratum belongs to the same geological horizon as that of Sterkfontein. Consequently it was a happy confirmation of our expectations when Mr. James Kitching came across an australopithecine occiput in this type of breccia during September 1947, while searching among the Limeworks dumps.

The new occiput (see photograph) exhibits an *Australopithecus* comparable in brain size to *Paranthropus robustus*, Broom, from Kromdraai. Owing to partial synostosis of the sagittal and lambdoid sutures the cranial fragment comprises the major portion of the occipital bone including most of the right margin of the foramen magnum and the posterior third of each parietal bone. It displays several significant humanoid anatomical features, namely, an expanded planum occipitale; an inferior situation of the inion relative to the opisthocranion and a consequent downward deflexion of the planum nuchale (thus proving the upright posture); the existence, but moderate development, of a torus transversus occipitalis (thus indicating the lack of a gorilloid 'bullneck' in the type) and the presence of a sutura transversa occipitalis (or sutura mendosa) with subsidiary sulci forming a complex 'Inca' bone (which has never been found hitherto in anthropoids).



Australopithecine occiput from the Makapansgat Valley

In all these features the Makapansgat *Australopithecus* distinguishes itself from its smaller-brained contemporary *Plesianthropus* at Sterkfontein. Further, if *Paranthropus* is geologically more recent (as Broom believes), the Makapansgat type probably differed considerably from *Paranthropus*. The final answer to this question must await the discovery of further remains.

But the most potent reason for separating the new fossil from its relatives is the difference between the bone breccia of Makapansgat Limeworks on one hand and the bone breccias of all the other manape sites on the other. The breccia shows first that the Makapansgat *Australopithecus* had advanced hunting habits and secondly that it was acquainted with the use of fire. Both of these inferences from the breccia were announced nine months before the discovery of the occiput in a communication to the First Pan-African Congress of Prehistory at Nairobi in January, 1947. They are briefly recapitulated here to explain why the name, *Australopithecus prometheus*, has been given to this specimen.

In addition to the Sterkfontein types of baboons such as *Parapapio broomi*, Jones, and *Parapapio jonesi*, Broom, the Makapansgat breccia has yielded fourteen species of Bovidæ, eight of which appear to be new; three carnivores (namely, lion, hyena and jackal); two extinct pigs; a rhinoceros; a hippopotamus; and two giraffes (including the extinct *Griquatherium*). Thus apart from the elephant we have concrete evidence that these creatures drew upon every family of big game found in Southern Africa for their food supply. The dentitions of the big game specimens, however, show that these Australopithecines were more frequently successful in slaying juvenile and aged representatives of these various mammalian families. But the profusion of the bone breccia shows that they were capable and successful in their hunting of very big game.

In 1925 the presence of *Australopithecus* was unsuspected because of the great size of these bones and their charred appearance—so the specimens of this Makapansgat Valley Limeworks bone breccia were submitted to two chemists (Drs. Moir and Fox) for analysis to discover whether the bones had been subjected to fire. From the great size of the beasts represented in the breccia, the intentional fracturing or splitting of the bones, and corroborative reports of the chemists relative to the presence of carbon, the deposit was claimed at that time as a primitive human kitchen midden. To-day it appears that all this 'human' activity at Makapansgat Limeworks site is the handiwork of man's australopithecine predecessors. No traces of stone implements have been found in the Makapansgat Limeworks strata nor have they been found at Taungs, Sterkfontein and Kromdraai. But we have found at Makapansgat a number of large ungulate humeri the epicondylar ridges of which were battered and broken and apparently as the result of deliberate use prior to their fossilization. Most of the bones are fresh and firm, and display clean

clear lines of gross fracture before fossilization, but others crack and crumble easily. These exhibit so fine a state of macroscopic and microscopic cracking as to preclude explaining their pre-fossilization fragmentation by the crude impact of stone or bone. The most likely force to have been responsible for their crumbling and altered condition is heat. That fire was the splintering agent is corroborated by their discoloration, disintegration and the chemical reports of free carbon made more than twenty years ago, and by the vesicular character of the adjacent glassy collophanites and clays recently discovered in the breccia by Dr. V. L. Bosazza and the comparative analysis he has made of ashy deposit from the breccia with ash from local Transvaal wood.

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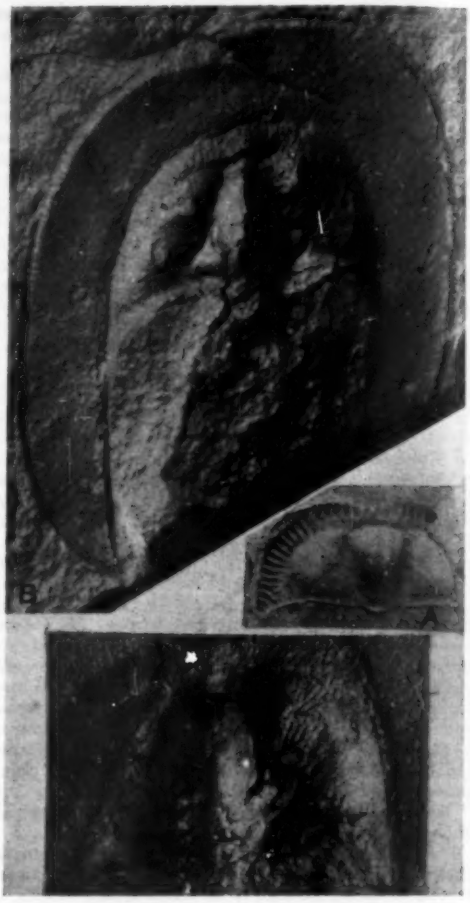
June 15.

Indications of Cephalic Sutures in Trinucleidæ and Harpedidæ

RUDOLF RUEDEMANN[1] in 1916 summarized the available evidence regarding traces of cephalic sutures in Trinucleidæ, Raphiophoridæ, Dionididæ, and Harpedidæ. The well-known marginal sutures in the first and last families he considered as secondary acquisitions. They are generally regarded as having facilitated ecdysis; but specimens are rarely found which have fractured along them. One might even draw a comparison between the marginal suture, which is nearer the dorsal than the marginal side of the brim, and the subcranial furrow of *Phacops* (*s.s.*). Ruedemann's reconstruction, especially of the anterior facial suture, from traces on internal moulds, is so interesting in the case of *Cryptolithus tesselatus* Green, in spite of P. E. Raymond's treatment[2] of the lateral eye-lines as genal cæca and not lateral parts of a facial suture, that for a number of years a look-out has been kept for corresponding evidence on the eastern side of the Atlantic.

In the case of *Cryptolithus* the search has not been rewarded; but in a number of internal moulds of *Trinucleus fimbriatus* Murchison, symmetrical breaks have been observed. For the most part only the remains of lateral (or posterior) facial sutures can be traced[3], but in a specimen recently obtained from Llan Fawr Quarry, near Llandrindod Wells, a semi-circular anterior facial suture appears to be present and to run just outside the anterior pits and forward into the fringe so as to enclose a number of pits of the innermost concentric row. This is different from what happens in *C. tesselatus*, in which Ruedemann makes the anterior facial suture pass inside the anterior pits and not cross into the pitted part of the fringe.

It is important, as shown in Fig. *A*, that the posterior parts of the suture are continuous with the anterior suture in *T. fimbriatus*. In *C. tesselatus* the genal cæca (Raymond) or lateral sutures (Ruedemann) do not join the frontal facial suture. So far as traces of facial sutures count, *Cryptolithus* seems to be further from the Opisthoparian ancestor than *Trinucleus*, and it may be suggested that in species which ploughed through mud the tendency was for the anterior suture to migrate away from and not towards the periphery of the fringe or brim.



A. Trinucleus fimbriatus Murchison, Llan Fawr Quarry (*Nemagraptus gracilis* Zone), north of Llandrindod Wells, × 2. *B. Scotoharpes domina* gen. et sp. nov., *Plectodonta* aff. *canastonensis* Siltstones, North Esk, Pentland Hills, × 3 (approx.). *C.* Part of the specimen shown in *B*, × 4

Good observations of posterior facial sutures have been made in *Scotoharpes domina* gen. et sp. nov., from fine Upper Gala silts of the Pentland Hills. On an external impression of the cephalon, a possible longitudinal suture was seen crossing the posterior border close to the glabella and running forward near the proximal side of an ala, where it was joined at right angles by a lateral suture bisecting the ala. This is even clearer on the internal mould (Fig. *B*, right side). Further examination suggests that the longitudinal suture cuts across the anterior extremity of the ala (Fig. *C*, right side). Perhaps its continuation is indicated by a scar which diverges outwards on the cheek towards the distal end of the genal cæcum. Possible traces of an anterior suture cannot be treated with certainty; but in Fig. *C* (left side) a fine ridge, indicating a furrow on the inside of the original cephalic shield, runs forward and then curves inwards towards the position of the first lateral furrow on the glabella. Attention may also be directed to the slight transverse angularity just in front of the glabella and even to the anterior furrow itself which separates inner and outer parts of the cheeks. Later-

ally this furrow is shallow, and on the left side where it approaches the distal end of the genal cæcum (Fig. *B*) a curvilinear raised ridge originates which runs back and then bends inward slightly to meet the posterior border. Can this conceivably mark the position of an early lateral or posterior suture at a stage when *Scotoharpes*, at least ancestrally, showed affinities with a genus like *Aulacopleura*? The possibility of such a relationship is supported by the recent work of Přibyl[4], in the general background of that by Stubblefield[5]. The definite suture close to the sides of the glabella suggests the condition in Olenidæ and Prœtidæ. *Prœtus loredensis* Delgado, in particular, has recently been compared with the Harpedidæ[6].

Ruedemann has suggested that the evolution of a genus like *Cryptolithus* has been marked by great lateral development of the cheeks. It is to this he attributes the length and parallelism of what he calls the "lateral facial sutures"[1]. While this may be true, one must also consider the likelihood of eyes migrating inwards and upwards on to the highest parts of the cheeks in a mud-dweller. Even if functional eyes were afterwards lost, the tendency for the migration towards the glabella appears to be supported by the course of the sutural traces in *Trinucleus fimbriatus*. Migration of eyes inward, possibly from the position of slight depressions behind the outer ends of the genal cæca in *Scotoharpes domina*, also may be arguable.

It is not easy to answer the question as to why traces of what may be facial sutures should remain on the inside of a cephalon of *Trinucleus fimbriatus*, unless they continued to serve as lines of easy splitting. In *Scotoharpes* the lateral and posterior sutures were evidently functional, and their presence on the ala may mean that the latter had a sensory function during ecdysis and perhaps at other times.

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Changes in the Incisor Teeth and Incisal Alveolar Bone of Rats in Hypervitaminosis A and Avitaminosis A

THE changes in bone in avitaminosis A have been reported by Mellanby[1], Wolbach and Bessey[2], and Wolbach[3], who consider that the vitamin is concerned with the control of bone modelling. Mellanby found excessive formation of bone in certain areas during avitaminosis and that the osteoblasts and osteoclasts could reverse their positions at the effective bony surfaces. Wolbach[3] considered that appositional bone formation continued in the normal site, but that concurrent resorption of bone ceased. Excessive doses of vitamin A have been found by many writers to cause spontaneous fractures of bones and internal hæmorrhages (see Moore and Wang[4] for a review of the literature). Wolbach[3] considered that bone remodelling was greatly accelerated and that a defective tissue was laid down.

The effects of vitamin A deficiency on the teeth are already well known[5]. A defective dentin is laid down by the odontoblasts, especially on the labial side. Pohto[6] and Wolbach[3] both reported that hypervitaminosis A has no effect upon the rat's incisor teeth.

Through the kindness of Dr. T. Moore and Mrs. S. E. Walker, of the Dunn Nutritional Laboratory, Cambridge, I obtained the heads of animals suffering from hypervitaminosis A. These were young rats and had been given 40,000 I.U. of vitamin A daily for 10–42 days. Their incisal alveolar bone and upper incisor teeth were examined microscopically. In the alveolus, the rate of bone formation was greatly reduced, many cementing lines were seen and active osteoblasts were much less prominent than usual. Osteoclasts appeared to be unaffected, so that the bone became abnormally thin and disappeared in places. In the teeth, only dentin formation was affected. This became decreased in appositional rate, the interfibrillar cementing substance was gradually reduced in amount, and the lingual odontoblasts had begun to atrophy.

The avitaminotic material studied was from rats previously investigated (Irving and Richards[5,6]). The animals had been on the vitamin-free diet used by us 28–53 days from weaning. The alveolar bones showed considerable over-production of new bone. This occurred in areas where apposition was usually seen and also in situations where resorption normally occurred. In the early stages of the deficiency, the osteoclasts endeavoured to overcome the latter abnormal apposition, while working alongside invading osteoblasts. Later they became displaced by osteoblasts and some osteoclasts were found on the opposite side of the bone. On faces where excessive apposition occurred in the usual site for apposition, osteoclasts were never found. The changes in the teeth in avitaminosis were the same as those reported by earlier workers.

It is concluded from these results that the primary action of vitamin A is upon the osteoblasts. Excessive dosage with vitamin A depresses the action of these cells, and, when the vitamin is lacking from the diet, these cells engage in disorderly overactivity. The reactions of the osteoclasts in avitaminosis are purely secondary, in an attempt to prevent excessive bone formation. In hypervitaminosis A these cells continue to act as usual. The odontoblasts, cells in the teeth comparable to the osteoblasts, react in a way similar to that of the bone-forming cells, producing less dentin in hypervitaminosis and excessive amounts in avitaminosis.

The expenses of this work were defrayed by grants from the South African Council for Scientific and Industrial Research and from the Staff Research Fund, University of Cape Town.

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Marine Fish Cultivation

In their recent review in *Nature*[1] of the papers on an experiment in marine fish cultivation by my colleagues and me[2], Cooper and Steven express the view, "that encouragement of fish growth in arms of the open sea such as the North Sea or the English Channel by the addition of plant nutrients can never be a paying concern". This categorical statement, based on a previous paper by Cooper[3], seems to bar once and for all any large-scale application of fertilizers to suitable parts of the sea. Leaving a fuller discussion to a forthcoming paper on fertilizer application in an open sea-loch, may I point out here that Cooper's arguments and figures do not, in my opinion, bear out his conclusion. For an assessment of the economics of fertilizing the sea we require figures showing: (*a*) the return in crop and stock per ton of fertilizer added to land, (*b*) the return in fish and shell-fish per ton of fertilizer added to the sea. The latter figures unfortunately do not exist. If our experiments have shown anything, it is the desirability of keeping an open mind to a rational approach to the whole problem of increasing the amount of human food growing in the sea, and pursuing research step by step along various lines, not excluding the fertilizing of suitable larger areas. As regards the threatening scarcity of phosphate, should it become necessary to recover it from the sea it may prove possible to extract it from water taken from greater depths of unproductive areas where the concentration of phosphate is high and its availability to plants low.

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We do not agree that the expression of a view is a "categorical statement" barring any door to further research. Be that as it may, we still consider that no evidence has yet been produced in support of the belief that encouragement of fish-growth by artificial fertilization of arms of the open sea, such as the English Channel or North Sea, can be made a paying concern. On the other hand, there is no little evidence in support of the opposite view. Perhaps the most convincing is the failure of Dr. Gross and his colleagues to demonstrate that marine fish cultivation could be made to pay even in a very tiny and almost completely enclosed body of water.

A large-scale fertilization of the sea is continuously in progress, for our method in the most advanced countries of disposing of the sewage of coastal towns achieves just this. The discharge from Plymouth, which must be considerable, affects the nutrient content of Plymouth Sound but is soon dissipated in the open sea beyond the breakwater. Its effect on the English Channel has rarely been notable. The problem would be most easily studied in an area already nutrient-poor, such as the Mediterranean and its adjacent seas. Such studies by Bernard[1] off Monaco and off Banyuls near the Franco-Spanish frontier, and by Ercegović[2] and Nümann[3] in the shallow northern Adriatic, do not seem to have found any appreciable enrichment by sewage. A quantitative assessment of the effect of sewage from large coastal cities discharging into seas of low natural nutrient resources should provide the readiest means of testing Ritchie's thesis which Gross again propounds.

Though there is a continuing exchange of the waters of the English Channel or the North Sea with the Atlantic Ocean, it is not easy to place a measure on it; it would seem to be large. The work of Proudman[4] suggests that the Irish Sea empties itself through the North Channel and is replaced through the St. George's Channel in a very few years, perhaps no more than two. The phosphate to be added to such arms of the sea, to do any good, would need to be measured in thousands of tons per annum. That part not quickly harvested as fish would vanish into the ocean in a year or two. Though it seems true that four-fifths of the phosphate added to arable land becomes tightly bound in the soil complex, some of it is still available to plants such as lupins which can get it out again; and given time enough, may not a saturation value be reached beyond which phosphate added to the soil remains freely available to plants? Be the answer to this what it may, there is a difference between immobilizing riches in a safe deposit and broadcasting them throughout the five oceans.

As to the last sentence of Dr. Gross's letter, it is always dangerous to try to foretell scientific development. Though the phosphate and nitrate resources of the deep ocean are enormous, the concentration rarely exceeds 90 μgm./l. of phosphate-phosphorus, or 0·000003 *M*. In the near future, no engine devised by man is likely to harness this reserve better than the vast oceanic circulation and upwelling impelled by winds on a global scale, followed by production of plants and animals. Fisheries in the most favoured regions provide the best means yet known or foreseen of exploiting this natural asset. Our heritage of bird guano and rock phosphate, upon which we are so dependent, represents the final stages of this process of enrichment of surface ocean water by upwelling of deep water. This heritage is being replaced more slowly than it is being spent; we ought not to hasten the wastage.

We do not wish to bar any development once and for all. Economic justification of marine research can come only from the application of our increasing knowledge to problems of production from the sea. None the less, fervid advocacy of a very costly programme, followed by practical failure, could only bring the science of the sea into ill repute. Surely the right approach is through small-scale experiments to larger ones, establishing firm experience as we go. The Loch Craiglin experiment on these lines was thoroughly sound and worthy of critical appreciation. This we attempted in our review.

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ARCTIC AEROBIOLOGY, II

PRELIMINARY REPORT ON FUNGI AND BACTERIA ISOLATED FROM THE AIR IN 1947

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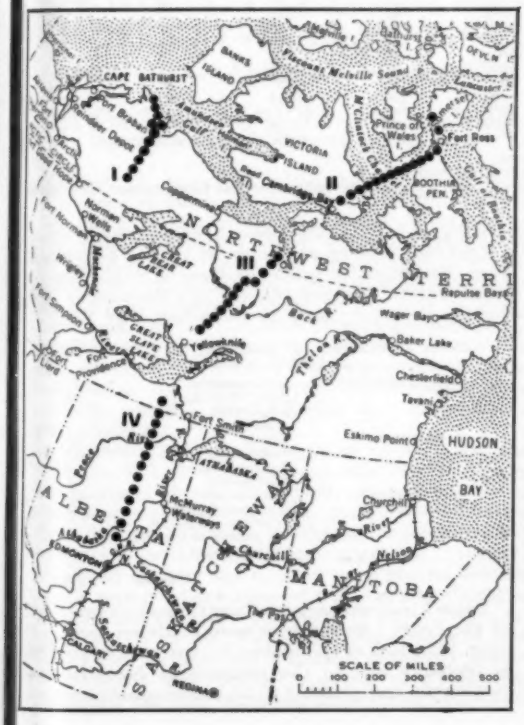
ALTHOUGH many studies have been made of the microflora of the air over temperate regions, little such work has been done in the Arctic. Meier and Lindbergh[1] made some preliminary studies by exposing petrolatum-coated slides at various points during Lindbergh's northern flight in 1933, six of these exposures being north of the Arctic Circle over Greenland. Owing to the death of Dr. Meier, only a brief report was published[2]. The following account presents the results of a series of exposures of nutrient plates in arctic and subarctic Canada in 1947, and also preliminary studies of the subcultures of bacteria and fungi obtained from these plates. The exposures were made by Prof. Polunin with the facilities provided by the Royal Canadian Air Force, of which a general account has recently been published[3]. 'Vaselined' slides were exposed at the same time for rust spores, pollen grains, etc., and the results of this examination will be published separately.



The medium employed was designed to allow minimal growth, since it was expected that a considerable time would elapse between exposure and arrival at the laboratory. Czapek's solution agar was accordingly modified by omitting the sucrose and adding yeast extract. On June 23 the first set of plates (standard 10 cm. Petri dishes) was prepared, using 0·4 per cent yeast extract; these plates were exposed on August 12. As it was found that micro-organisms made good growth on this medium, it was deemed advisable to modify further the formula; accordingly the yeast extract was reduced to 0·1 per cent, and the agar content increased to 2·5 per cent. This second lot of medium was prepared on July 14 and was used in the remaining flights. In both cases the poured plates were left for one week at room temperatures and any that showed contamination were discarded. Details of the wrapping of the plates and the technique of exposure have already been described[3].

Following exposure, each plate was carefully rewrapped and packed, the complete stock of exposed and unexposed plates being kept together until the work was completed in early September. When the plates were returned to the laboratory on September 12 and 13 they were in excellent condition, all showing numerous small colonies of micro-organisms. Seven unexposed plates were carried throughout, and these were sterile when returned to the laboratory and remained so even after one month at room temperature.

The relatively slow air-speeds (see Table 1) made exposure by hand feasible, and the plates were held at a minimum of 20 cm. from the fuselage. Flight 1 was made in a Norseman aircraft which has a single propellor situated in front of the nose, so that these plates (1 to 11) may have been affected by the turbulence caused by the propellor. Flights II to IV were made in a twin-engined Canso flying boat in which the propellors are behind the co-pilot's seat from which the exposures were made; this permitted an unobstructed air stream to strike the plates (12 to 52).

The attempt was made to obtain exposures every 20 or 30 miles in a series of flights that would extend from temperate regions as far north as possible. Of the four flights (see accompanying map), one was near the extreme north-west of Canada and reached as far as the Arctic Ocean, while the remainder extended from Somerset Island to Edmonton, Alberta.

No attempt was made to obtain cultures from all of the colonies in any one plate, only those in which the colonies were well isolated and uncontaminated being used. Despite this precaution, many of the cultures proved to be contaminated, due possibly to several micro-organisms being present on a dust particle. In some cases, examination with a dissecting microscope revealed numerous microscopic bacterial colonies within the mycelium, and these colonies were readily transferred along with portions of the fungous hyphæ. It was believed that these tiny bacterial colonies (which were not included in the counts) either found the medium to be unfavourable or were inhibited by the fungi. Similarly, minute fungous colonies were also noted, although much less frequently: two such colonies when transferred to corn meal agar failed to grow.

The numbers of colonies of bacteria and fungi are given in Table 1 along with relevant data. It is evident that bacteria greatly outnumber fungi in most of the fifty-one plates exposed.

Table 1. Results of two-minute exposures of nutrient plates

Plate No.	Hour	Airspeed m.p.h.	Lat. N.	Long. W.	Alt. (ft.)	No. of colonies: Bacterial Per plate	Bacterial Per cu. ft.[1]	Fungal Per plate	Fungal Per cu. ft.[1]
Flight I, from Canso Lake to Cape Bathurst (Plates 1–11), August 12.									
1 *B*	18·24	90	67° 38′	127° 8′	3200	60	0·059	8	0·0079
2 *B*	18·34	105	67° 58′	126° 53′	5100	23	0·019	7	0·0058
3 *B*	18·44	110	68° 12′	126° 28′	5100	46	0·02	7	0·0057
4 *B*	18·54	112	68° 32′	126° 05′	5100	38	0·026	4*	0·0027
5 *B*	19·04	115	68° 54′	126° 02′	5100	16	0·0093	2*	0·0012
6 *B*	19·14	110	69° 06′	125° 43′	5150	32	0·026	0	—
7 *B*	19·24	110	69° 24′	125° 30′	5350	32	0·026	1	0·0008
8 *B*	20·26	90	Circling over pt.		4000	24	0·024	4	0·0039
9 *B*	20·35	100	69° 28′	125° 48′	5100	33	0·029	11	0·0096
10 *B*	20·45	110	69° 51′	126° 34′	5100	19	0·015	4	0·0032
11 *B*	20·55	115	70° 02′	126° 54′	1500	14	0·008	15	0·0087
Flight II, from Cambridge Bay to Somerset Island (Plates 13–27), August 26.									
13 *B*	5·17	113	69° 32′	103° 33′	3500	530	0·454	12	0·01
14 *B*	5·27	109	69° 45′	102° 55′	3000	400	0·324	14	0·011
15 *B*	5·37	115	69° 57′	102° 15′	4200	290	0·224	9	0·0069
16 *B*	5·47	115	70° 09′	101° 32′	4300	180	0·139	8	0·0064
17 *B*	5·57	116	70° 20′	100° 55′	4400	95	0·07	7	0·0051
18 *B*	6·07	115	70° 33′	100° 06′	4200	38	0·029	5	0·0039
19 *B*	6·17	115	70° 44′	99° 20′	4000	60	0·046	6	0·0047
20 *B*	6·27	116	70° 57′	98° 30′	4050	43	0·033	8	0·006
21 *B*	6·37	116	71° 08′	97° 40′	4200	45	0·034	3	0·0023
22 *B*	6·47	116	71° 20′	96° 50′	4100	95	0·075	6	0·0046
23 *B*	6·57	116	71° 31′	96° 00′	4100	112	0·083	6	0·0046
24 *B*	7·07	117	71° 43′	95° 10′	4000	74	0·056	8	0·0061
25 *B*	7·17	121	71° 54′	94° 05′	4000	89	0·064	102**	0·074
26 *B*	7·42	119	72° 34′	94° 25′	5000	47	0·044	3	0·0023
27 *B*	8·01	117	72° 38′	94° 28′	4500	79	0·08	12	0·009
Flight III, from Cambridge Bay to Yellowknife (Plates 28–39), August 27.									
28 *B*	9·38	109	66° 45′	108° 20′	4600	328	0·265	24	0·02
29 *B*	9·53	104	66° 27′	108° 47′	5500	185	0·158	10	0·0086
30 *B*	10·08	117	66° 05′	109° 18′	7300	124	0·092	15	0·013
31 *B*	10·23	109	65° 45′	109° 47′	6300	78	0·063	8	0·0065
32 *B*	10·38	109	65° 25′	110° 14′	6400	54	0·048	6	0·0049
33 *B*	10·53	115	65° 06′	110° 40′	6000	92	0·071	5	0·0039
34 *B*	11·08	115	64° 44′	111° 10′	5900	59	0·046	2	0·0015
35 *B*	11·23	115	64° 24′	111° 35′	5600	33	0·039	1	0·0008
36 *B*	11·38	115	64° 04′	111° 58′	5500	67	0·052	7	0·0054
37 *B*	11·53	115	63° 45′	112° 27′	5100	61	0·047	5	0·0039
38 *B*	12·08	115	63° 27′	112° 57′	5000	46	0·036	4	0·0031
39 *B*	12·23	117	63° 06′	113° 27′	4600	81	0·063	2	0·0015
Flight IV, from Yellowknife to Edmonton (Plates 40–52), September 5.									
40 *B*	8·38	115	60° 11′	114° 00′	5000	196	0·151	19	0·015
41 *B*	8·53	115	59° 46′	113° 58′	5000	71	0·055	33	0·025
42 *B*	9·08	115	59° 20′	113° 58′	5000	75	0·058	6	0·0046
43 *B*	9·23	115	58° 54′	113° 57′	5000	41	0·032	3	0·0023
44 *B*	9·38	117	58° 28′	113° 56′	5000	40	0·031	7	0·0054
45 B	9·53	117	58° 02′	113° 55′	5000	49	0·038	11	0·0085
46 *B*	10·09	119	57° 35′	113° 54′	5000	37	0·028	18	0·014
47 *B*	10·23	119	57° 11′	113° 53′	5000	21	0·016	11	0·0083
48 *B*	10·38	119	56° 46′	113° 52′	5000	80	0·06	32	0·024
49 *B*	10·53	119	56° 18′	113° 51′	5000	105	0·075	67	0·05
50 *B*	11·08	119	55° 52′	113° 50′	5000	147	0·11	79	0·052
51 *B*	11·23	119	55° 26′	113° 49′	5000	62	0·046	111	0·083
52 *B*	11·38	120	55° 00′	113° 48′	5000	476	0·35	306	0·23

* One contaminant observed immediately following exposure.
** Mostly secondary colonies from large central one of sporulating *Penicillium*.
[1] Figures computed from time of exposure, speed of aircraft, and area of plate: it should be emphasized that they represent comparative rather than precise quantitative values.

Table 2 summarizes the subcultures that were made from representative bacterial colonies, in forty-five of the fifty-one plates. Transfers were not made from the other six plates because of bacterial spreaders, or because the colonies were covered with mould. All the subcultures were made on to nutrient agar slopes.

Wolf[4], in studies of the air over Nashville, Tenn., and Proctor and Parker[5] over Boston, found spore-forming bacteria comprising a high percentage of their colonies (37·7 and 52·2 per cent, respectively) and a low percentage of Gram-positive non-spore-forming rods. In the present investigation about 5·0 per cent were spore-formers and about 41 per cent were Gram-positive non-spore-forming rods. On the other hand, the percentages of *Micrococcus* and *Sarcina* were very close to those found by Wolf[4].

Table 2. Summary of preliminary study of bacterial cultures

Micrococcus	43
Sarcina	5
Achromobacter (probably)	8
Achromobacter or *Flavobacterium*	24
Gram-positive rods (unclassified)	20
Gram-positive rods morphologically like *Corynebacterium*	46
Spore-formers	8
No growth on transfer	21
Mixed cultures	13
Total	188

Table 3. Summary of preliminary identification of fungous cultures

Fungi Imperfecti	*Hormodendrum*	33
	Other Moniliales	20
	Phyllosticta	1
	Pestalozia	1
Ascomycetes	Yeasts	16
	Penicillium	15
	Leptosphaeria	9
	Chaetomium	1
Actinomycetales	*Streptomyces*	22
Other cultures	Non-sporulating	74
	Sclerotia-producing	2
	No growth on transfer	9
	Contaminated	4
	Total	207

Table 3 is a summary resulting from an examination of the fungi. Subcultures were made on corn meal agar. The lack of sporulation in many of the cultures is probably due to the presence of bacterial contaminants, and possibly to an unfavourable medium.

These cultures will be purified and grown on various media in order to induce sporulation, and a detailed report including identifications will be published later. The almost universal prevalence of *Homodendrum* in the air as indicated by many workers, including Wolf[4], Proctor and Parker[5], Meier and Lindbergh[1], is confirmed by its occurrence in 33 of the 207 cultures (15 per cent). Conspicuously absent among the sporulating cultures were *Aspergillus*, *Fusarium* and Phycomycetes.

On the basis of the colonies which developed in our plates, it would appear that bacterial cells greatly outnumber fungus spores in the arctic air. There appears to be no correlation between the number of colonies and geographical position, at least within the arctic and subarctic regions. However, in the region of Edmonton an increase of both bacterial and fungous floras was found which may possibly be related to areas of cultivation.

No explanation can be given for the high numbers of bacterial colonies encountered in the vicinity of Cambridge Bay on two successive days. The highest count was found on August 26 on plate 13 exposed some 50 miles north-east of Cambridge Bay, and high numbers were also found in plates 14, 15, 16 exposed still farther north. High counts were again obtained the following day on plates 28 to 30, plate 28 being exposed some 170 miles south-west of Cambridge Bay.

[1] Meier, F. C., and Lindbergh, C. A., *Sci. Mon.*, **40**, 5 (1935).
[2] Meier, F. C., *Phytopath.* (Abs.), **25**, 27 (1935).
[3] Polunin, Nicholas, Pady, S. M., and Kelly, C. D., *Nature*, **160**, 876 (1947): *see* also *Arctic*, **1**, 60 (1948).
[4] Wolf, F. T., *Bull. Torr. Bot. Club*, **70**, 1 (1943).
[5] Proctor, B. E., and Parker, B. W., *J. Bact.*, **36**, 175 (1938).

FORMATION OF HYDROGEN PEROXIDE IN WATER IRRADIATED WITH X- AND ALPHA-RAYS

By Dr. P. BONET-MAURY and M. LEFORT
Laboratoire Curie, Institut du Radium, Paris

IN spite of numerous studies, the primary action of ionizing radiations on water is not yet fully known. Knowledge of this action is important in relation to the radio-chemistry of dilute aqueous solutions and is required for the better understanding of the mechanism of the biological effect of these radiations, since water comprises about 80 per cent of living organisms. As the formation of hydrogen peroxide is regularly demonstrable in irradiated water[1], a systematic investigation of this phenomenon has been undertaken for radiations of very different ionic density, namely, 0·9 A. X-rays and polonium or radon α-rays.

Methods. The irradiation with X-rays and the titration of hydrogen peroxide were carried out by the methods already described[2]. In order to study the effect of dissolved oxygen, gases were eliminated from the water *in vacuo* by alternate evacuation and saturation with oxygen-free argon or nitrogen. Dissolved oxygen was titrated by a special method which permitted the assay of a 30-c.c. water sample, and the estimation of 0·2 mgm. of oxygen with an accuracy of 5 per cent. A control sample was assayed in an identical manner. Dissolved radon[3] or polonium was used as a source of α-radiation. Polonium was only employed under conditions which

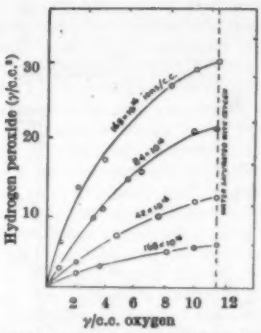


Fig. 1. Influence of dissolved oxygen. Doses of radiation: 168, 84, 42 and 16·8 × 10^{14} respectively

were such that the catalytic effect of this substance[4] on the decomposition of hydrogen peroxide was negligible.

Effect of Dissolved Oxygen. (*a*) *X-rays.* For a given dose of radiation, the amount of hydrogen peroxide produced depends markedly upon the concentration of dissolved oxygen (Fig. 1). In water carefully freed from gas, it is no longer possible to detect any hydrogen peroxide, even after exposure to doses as high as 1·7 × 10^{18} pairs of ions/c.c., or more than 2,000,000 r. (surface dose).

(*b*) *α-rays.* The ionic yield, in the case of X-rays, suggests that the radon β-rays probably account for less than 5 per cent of the total effect of the α+β-radiation. We have verified this fact directly, using only the action of the β-radiation, α-rays being stopped by a vial of thin glass containing the radon and directly immersed in the titanium reagent. When water was exposed to the α-radiation from dissolved radon and its disintegration products, the following results were obtained. In water completely freed from gas and therefore containing no oxygen which could take part in the reaction, the ionic yield of hydrogen peroxide was found to be the same as in oxygen-saturated water. The same result was obtained when polonium α-radiation was used; but the experiments in this case were complicated by the catalytic effect of the radio-element, which tended to decompose the hydrogen peroxide produced. When initial radon concentrations of 1–3 mc./c.c. were used, the ionic yield was independent of the dose within the whole interval tested (Fig. 2). (The ionic yield is,

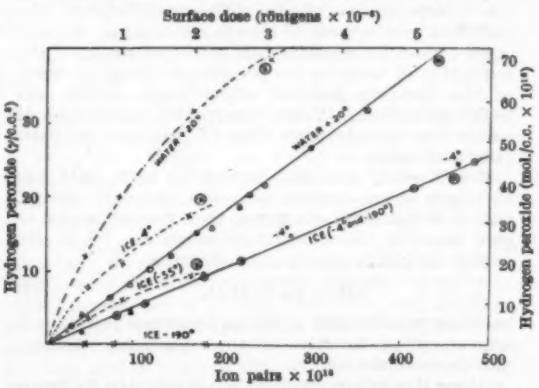


Fig. 2. The curves refer to water (+ 20°), ice (− 4°), water (+ 20°), ice (− 55°), ice (− 4° and − 190°) and ice (− 190°)

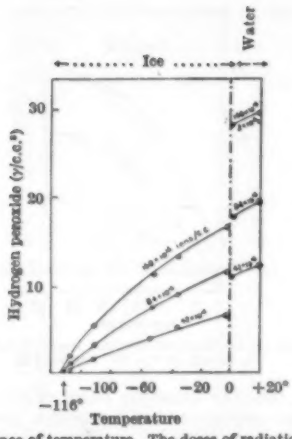


Fig. 3. Influence of temperature. The doses of radiation (reading from the top) are 168, 84 and 42 × 10^{18} ions/c.c. for ice; and similarly for water

of course, generally defined as the ratio of the number of molecules decomposed to that of ion pairs produced; this definition is not applicable to hydrogen peroxide formation, because the number of water molecules decomposed is not directly known.)

Temperature Effect. (*a*) *X-rays.* In oxygen-saturated water, the production of hydrogen peroxide decreases regularly with the temperature, a definite discontinuity marking the passage from water to ice (Fig. 3). Below −116°, it is no longer possible to detect any hydrogen peroxide, even when the dose is 2 × 10^{8} r. (Fig. 3).

(*b*) *α-rays.* The temperature seems to be without influence on the production of hydrogen peroxide in water and ice by the α-radiation from dissolved radon. At the transition point from water to ice, a discontinuity similar to that of X-rays was observed (Fig. 1). Polonium α-rays give similar qualitative results, the catalytic effect of the radio-element being considerably decreased as the temperature is lowered.

Discussion. The experimental results show that hydrogen peroxide is formed according to different mechanisms for X- or α-rays, and that the linear ion density of the radiation affects the primary reactions concerned with the decomposition of the water.

These data are perfectly concordant with the hypothesis suggested by some British workers[5] for the interpretation of the differences between the radiobiological effects of X-rays and α-rays. According to those conceptions, the principal result of the ionization of water is the production along the track of the ionizing particle of hydrogen atoms and hydroxyl radicals (Weiss), the spatial distribution of which corresponds with that of primary ion pairs (Lea and Gray).

For X-rays, the distribution is such that the hydrogen atoms remain near the hydroxyl groups, and, in the absence of oxygen, their recombination to give water is the most likely reaction. When dissolved oxygen is present, the reaction

$$2H + O_2 = H_2O_2 \qquad (1)$$

becomes possible and produces hydrogen peroxide in amounts which increase with the oxygen concentration and the temperature.

Along the trajectory of an α-particle, the hydroxyl groups remain concentrated in the centre of the ionization column and are at first isolated from the hydrogen atoms which form a surrounding sheath. The reaction

$$OH + OH = H_2O_2 \qquad (2)$$

is the most likely, and it produces hydrogen peroxide even in the absence of dissolved oxygen; the reaction seems to be independent of the temperature. The constant ionic yield for α-rays indicates that, when oxygen is present, the amount of hydrogen peroxide produced according to reaction (1) is negligible compared with that produced according to reaction (2).

From these results, it appears that hydrogen peroxide plays an important part in the mechanism of the biological effect of radiations, since its formation seems to be one of the radiochemical primary reactions produced in aqueous media exposed to ionizing radiations.

The remarkable constancy of the ionic yield with α-rays shows that the photocolorimetric method is particularly convenient for the radiochemical dosage of dense ionizing radiations such as recoil protons or neutrons.

[1] Bonet-Maury, P., *C.R. Soc. Biol.*, **135**, 941 (1941). Latarjet, R., *C.R. Acad. Sci., Paris* (1942).
[2] Bonet-Maury, P., and Frilley, M., *C.R. Acad. Sci., Paris*, **218**, 400 (1944).
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NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY

THE annual conference of the National Institute of Industrial Psychology was held in Buxton during April 9–12, and a report has now been issued ("Psychology at Work", **1**, No. 3; July 1948). Welcoming the delegates to the Conference, the chairman of the Institute, General Sir Ronald Forbes Adam, stated that everywhere in industry management is facing the fact that output must be raised if Britain is to retain its standard of life; but the re-equipping of industry is going to take a long time and some means must be found of achieving the goal more quickly. It has now been generally realized that this increase in output can be achieved if greater attention is paid to human relationships; but there has been too little research into this problem. The aim of the Conference was to discuss some of the fundamental issues of human relationships, and its purpose can be summed up in three questions: (1) How much knowledge on the subject exists? (2) Is the knowledge readily available and is it being utilized? (3) What research can be undertaken?

The first session of the Conference was grouped under the heading "The Man and the Job" and, in the first address, Mr. Robert Watson, chief personnel officer to the Philips group of electrical companies, discussed the selection and allocation of workers. In a recent attempt to check selection and placement practices in industry, Mr. Watson and his colleagues sent out a questionnaire to about two hundred firms in many industries. Replies were obtained from sixty-three firms, including a high proportion of the acknowledged better employers, employing altogether about 300,000 persons. Of the sixty-three firms, four

employed full-time psychologists; fifty-two did not give special training to employment interviewers and fifty-three companies did not use job specifications. Forty-eight companies did not give dexterity tests to hourly-paid operators, and fifty-three companies did not give intelligence tests to hourly-paid operators. From this and other data supplied by Mr. Watson it seems reasonably certain that few companies are taking advantage of the latest psychological developments in the use of selection methods. If companies could be persuaded to make use of modern employment practices it would do much to reduce the heavy burden of labour turn-over costs which help to inflate the price of the finished article. While it is not easy to obtain the costs of labour turn-over in any one industry, figures obtained from a firm employing 4,500 females and 3,380 males on mass production work showed that there is a labour turn-over in 1947 of 56 per cent of the total female hourly-paid workers and 38 per cent of the male workers; of those who left the firm during the year, 67 per cent of the women and 72 per cent of the men were in their first year of service.

In a paper on training and working methods, Colonel B. Ungerson, chief psychologist, Directorate of Manpower Planning at the War Office, described the methods which give best results in providing training for unskilled and semi-skilled jobs. Instead of the existing method of placing a newcomer with an experienced operator and telling him to get on with the job, Colonel Ungerson suggested that the efficiency of a department would be considerably improved if newcomers were given definite training under competent instructors. This training should include the presentation of knowledge which would include the most suitable tools for the job, when they were satisfactory for use, what raw materials were used for which jobs and so on. This should be supplemented by as many practical aids as possible, including diagrams, models (or the real thing if possible) and a museum of faults; these should apply both to raw materials and finished products. The problem of developing skill is to ensure a repetition of good movements until they become habitual; this should be based upon movement study and is not necessarily complex. Colonel Ungerson then gave some examples of how skill could be developed in various unskilled and semi-skilled jobs.

Following the papers by Mr. Watson and Colonel Ungerson, the Conference divided into eight discussion groups which reported their findings to the Conference at the end of the first day. Summing up the findings of the groups, the chairman, Lord Piercy, said that we are faced with the problem of more production with a given labour force. We can only cut our costs by three means: education, application of what is known, and research. In the field of the education of management we are not yet getting the full benefit out of good practice and, although there will be 'sales resistance' all the way down the management chain, we must get the practice of good firms accepted by others. In the application of particular items of information he was impressed by the stress which has been laid on training as opposed to selection. Training undoubtedly is the key to prompt results, but the individual as a whole should be considered, and here selection is important. On the subject of research it is necessary to pool all our ideas. The problem of the use of individuals of low mentality might profitably be pursued further, and it is pleasing to report that over the last year the Government has come to realize the importance of this work; Panel 3 of the Committee on Industrial Productivity was specially charged with the consideration of the human factors affecting production.

The second session was grouped under the general heading, "The Firm as a Working Unit". Mr. Graham Satow, director of training, Stewarts and Lloyds, Ltd., in a paper on the supervisory grades, traced the development of a changed outlook among workpeople and into this background fitted the position of the foreman and his problems. The same difficulties seem to be encountered on both sides of the Atlantic, and he suggested that the two aims should be to strengthen the foreman's status in the firm and to develop a changed pattern of leadership in the supervisory grades. Mr. Satow then made many practical suggestions as to the methods in which these aims could be realized.

Probably the highlight of the Conference, however, was the paper by Mr. W. L. Mather, director of Mather and Platt, Ltd., on communication within the firm. Borrowing from his experience at the Army Staff College, Mr. Mather gave a practical demonstration of the way in which two-way communication could take place within the firm. Two boards were placed in front of the audience, one of which was marked "Management" and the other "Workers". Between these two there was a gap which, he said, represented the gap between management and workers about which so much was being talked at the present time. The problem is to bridge the gap. Very useful bridges across the gap are provided by personnel departments, works committees, joint production consultative and advisory committees, general committees, training, notice boards, broadsheets, magazines, suggestions schemes, lectures and verbal instructions. These bridges can easily be broken, however, and with a compelling dramatic presentation in which he was helped by a typical British workman, Mr. Mather showed how the only real way of providing communication in any firm is by personal contact.

After further discussion, the second session was summed up by Sir Godfrey Ince, permanent secretary to the Ministry of Labour and National Service, who stated that he was glad that the Conference emphasized the problem caused by the changed outlook of the worker. To find the right relationships between the man and the job involves using the right methods of selection, training and allocation, and use can be made of the Ministry of Labour's experience both with the Juvenile Employment Service and in providing supervisory training through the Training within Industry Scheme.

The final address to the Conference was given by Mr. Austin Albu, deputy director, British Institute of Management, who said that it is the variation between firms which has to be considered when approaching our industrial problems. Some British firms have employed methods which equal those of any other country, and the need is to bring all firms as near as possible to this standard. This can be done, first, by selling ideas to management; secondly, by breaking down the resistance of trade unions and abolishing restrictive practices generally; and thirdly, by training first-line supervisors. The Conference has profitably discussed ways in which these things can be done, and it is hoped that the British Institute of Management will soon be able to be of direct service to industry.

T. H. HAWKINS

FORTHCOMING EVENT

Thursday, September 9

UNIVERSITY OF MANCHESTER (in the Physical Laboratories, Manchester).—Discussion on "Meteors" (to be opened by Dr. F. L. Whipple).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (temporary), and a DEMONSTRATOR, IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Leeds 2 (September 10).

DEMONSTRATOR IN CHEMISTRY AND BIOCHEMISTRY with a special interest in Physical Chemistry—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (September 11).

ASSISTANT LECTURERS (3) IN THE DEPARTMENT OF CIVIL ENGINEERING, to assist in the subjects of Theory of Structures and Fluid Mechanics—The Professor of Civil Engineering, City and Guilds College, South Kensington, London, S.W.7 (September 13).

LECTURER (woman) IN GEOGRAPHY, and an ASSISTANT LIBRARIAN (man or woman)—The Warden, Goldsmiths' College, New Cross, London, S.E.14 (September 14).

TECHNICAL ASSISTANT (man or woman, Grade B) for experimental research work in the Zoology Department—The Registrar, University College of North Wales, Bangor (September 15).

LECTURER IN EXPERIMENTAL PHARMACOLOGY—The Secretary, The University, Aberdeen (September 15).

LECTURER IN BOTANY at Farouk I University, Alexandria—The Director, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (September 15).

RESEARCH OFFICERS (4), ASSISTANT RESEARCH OFFICERS (5), and RESEARCH ASSISTANTS (3), in the Board of Trade—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 2267 (September 16).

RESEARCH ASSISTANT (with Honours Degree in Botany and, if possible, some practical experience in Horticulture) to work on Strawberry Breeding—The Secretary, School of Agriculture, Cambridge (September 25).

ASSISTANT LECTURERS (2) IN ANATOMY—The Secretary, University College, Gower Street, London, W.C.1 (September 25).

DEPUTY CURATOR at the Horniman Museum, London Road, London, S.E.23—The Education Officer (Estab/2), County Hall, Westminster Bridge, London, S.E.1 (September 30).

CONTROLLER OF TELECOMMUNICATIONS, Civil Aviation Branch, Air Department, Wellington—The Office of the High Commissioner for New Zealand, 415 Strand, London, W.C.2 (September 30).

LECTURER IN ELECTRICAL ENGINEERING at the University of the Witwatersrand, Johannesburg—The Secretary, Universities Bureau of the British Empire, 32 Woburn Square, London, W.C.1 (October 1).

TECHNICIAN to take charge of Medical Unit Laboratory—The Secretary, St. Mary's Hospital Medical School, Praed Street, London W.2 (October 1).

LECTURER IN GENERAL BACTERIOLOGY, and a RESEARCH ASSISTANT AND DEMONSTRATOR (temporary) IN BOTANY—The Registrar, University College of South Wales, Cathays Park, Cardiff (October 2).

CHAIR OF EXPERIMENTAL PHYSICS, and an ASSISTANT PROFESSOR OF EXPERIMENTAL PHYSICS, in the University of Geneva—Le Conseiller d'Etat charge du Departement de l'Instruction Publique, 6 rue de l'Hotel-de-Ville, Geneva, Switzerland (October 15).

READERSHIP IN PHYSIOLOGY at St. Bartholomew's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 18).

STUDENTSHIPS (4) at a British (or, exceptionally, foreign) research institute in preparation for Fisheries Research in the Colonial Empire—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1 (October 31).

SENIOR LECTURER or LECTURER IN CHEMISTRY at Canterbury University College, Christchurch, New Zealand—The Secretary, Universities Bureau of the British Empire, 32 Woburn Square, London, W.C.1 (November 1).

READERSHIP IN PHYSICS (in the field of Metal Physics) at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 4).

LECTURERS IN PHYSICS, a LECTURER IN THE DEPARTMENT OF MATHEMATICS, and a SENIOR ASSISTANT IN THE SCHOOL OF CHEMISTRY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

INSPECTOR OF MINES (to act also as Inspector of Quarries and Explosives and Technical Adviser to the Mining Board) in the Department of Lands, Mines and Surveys, Fiji—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

BOTANISTS (to undertake the improvement of economic plants by selection and breeding, and to investigate and control plant disease) in Nigeria—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

SENIOR TECHNICIANS (2) IN THE NATIONAL BLOOD TRANSFUSION LABORATORY, Cardiff—The Regional Blood Transfusion Officer, 19 Newport Road, Cardiff.

SENIOR LABORATORY STEWARD (Chemistry and Biology)—The Bursar, Merchant Taylor's School, Sandy Lodge, Northwood, Middx.

LABORATORY ASSISTANT—The Headmistress, Godolphin and Latymer School, Hammersmith, London, W.6.

LABORATORY ASSISTANT IN THE CHEMICAL LABORATORIES—The Principal, County Technical College, Stoke Park, Guildford.

LABORATORY TECHNICIAN—The House Governor, Skin Hospital, John Bright Street, Birmingham 1.

LECTURER IN CHEMISTRY to Intermediate B.Sc. stage—The Principal, Medway Technical College, Gardiner Street, Gillingham, Kent.

LECTURER IN THE NATURAL PHILOSOPHY DEPARTMENT—The Secretary, Royal Technical College, Glasgow.

ASSISTANT LECTURER IN AGRICULTURE, and a DEMONSTRATOR IN CHEMISTRY—The Registrar, The University, Nottingham.

PRINCIPAL MEDICAL OFFICER/RESEARCH (bacteriologist with good experience of original research), a PRINCIPAL SCIENTIFIC OFFICER (bacteriologist with good experience of original research), a PRINCIPAL SCIENTIFIC OFFICER (biochemist with first- or second-class honours degree and good experience in original research), and MEDICAL OFFICERS/RESEARCH (bacteriologists or experimental pathologists with experience of original research), in the Microbiological Research Department of the Ministry of Supply—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2274.

BIOCHEMIST to undertake establishment and direction of biochemistry research and development laboratory in Serum Institute, Naples—The Secretary, Wright-Fleming Institute of Microbiology, St. Mary's Hospital, Paddington, London, W.2.

ENGINEER specializing in drilling and blasting operations (Ref. TT.76), an ENGINEER specializing in shaft sinking and tunnelling operations (Ref. TT.77), and an ENGINEER specializing in mechanical stowage (Ref. TT.78), in the Production Department in London—The National Coal Board, Establishments (General) Branch, Hobart House, Grosvenor Place, London, S.W.1, quoting the relevant Ref. No.

AGRICULTURAL CHEMIST IN THE AGRICULTURAL DEPARTMENT of the Government of Kenya—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

SENIOR METEOROLOGICAL OFFICER for the Government of Falkland Islands Dependencies Survey for service in the Antarctic—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.21628/3E.

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